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REDESIGNED ROTOR FOR A HIGHLY LOADED, 1800 FT/SEC TIP SPEED COMPRESSOR FAN STAGE
I. AERODYNAMIC AND MECHANICAL DESIGN

by

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16. Abstract

A highly loaded, high tip-speed fan rotor was designed with multiple-circular-arc airfoil sections as a replacement for a marginally successful rotor which had precompression airfoil sections. The substitution of airfoil sections was the only aerodynamic change.

The rotor has a tip speed of 548.6 m/sec [1800 ft/sec], axial inlet flow, a hub-tip ratio of 0.5, and an aspect ratio of 2.78. Design corrected flow is 78.8 kg/sec [173.8 lbm/sec]; flow-per-unit-annulus-area at the rotor inlet is 188.9 kg/m^2-sec [38.7 lbm/ft^2-sec]; rotor pressure ratio is 2.34; and efficiency is 0.870. A spanwise distribution of rotor pressure ratio was selected which gives a predicted stall margin of seven percent at design speed.

Structural design of the redesigned rotor blade was guided by successful experience with the original blade. Only those changes were made that were necessitated by the substitution of the airfoil sections. Calculated stress levels and stability parameters for the redesigned rotor are within limits demonstrated in tests of the original rotor.

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SUMMARY

A highly loaded, high tip-speed fan rotor was designed with multiple-circular-arc (MCA) airfoil sections as a replacement for a marginally successful rotor which had precompression (PC) airfoil sections. The substitution of MCA airfoil sections in place of PC sections is the only aerodynamic change to the original stage design.

The rotor has a tip speed of 548.6 m/sec [1800 ft/sec], axial inlet flow, a hub-tip ratio of 0.5, and an aspect ratio of 2.78. Design corrected flow is 78.8 kg/sec [173.8 lbm/sec]; specific flow (flow per unit annulus area) is 188.9 kg/sec m^2 [38.7 lbm/sec-ft^2]; rotor pressure ratio is 2.34; and efficiency is 0.870 based on loss data from high Mach number MCA rotors. A spanwise distribution of rotor pressure ratio was selected which gives a predicted stall margin of seven percent at design speed. Based on stator losses measured in previous tests, the estimated stage pressure ratio is 2.285 and stage adiabatic efficiency is 0.837.

Design values of incidence and deviation angles and of minimum critical-area ratios (A/A^*) in channels between blades were selected based on criteria used successfully in other MCA airfoil designs. Throat areas in channels were increased in the region of the partspan shroud to compensate for its blockage. Evaluations of shock-starting criteria indicate that this MCA blade design could operate with attached oblique shocks over the outer 63 percent of span at design speed and flow.

Structural design of the MCA rotor blade was guided by successful experience with the original blade. Only those changes were made that were necessitated by the substitution of the MCA airfoil section in place of PC sections. Calculated stress levels and stability parameters for the MCA rotor are within limits demonstrated in tests of the original rotor.

INTRODUCTION

Advanced aircraft require compact, lightweight fans and compressors which are efficient and stable over a wide range of operation. Pressure ratio per stage can be raised above current levels by increasing wheel speed and loadings. A stage having a rotor tip speed of 487.7 m/sec [1600 ft/sec] demonstrated a pressure ratio of 1.84 with an adiabatic efficiency of 0.843 and 15% stall margin (ref. 1).

A 548.6 m/sec [1800 ft/sec] tip-speed fan program was undertaken in an attempt to increase stage pressure ratio through the use of higher rotor speed while maintaining useful levels of efficiency and stall margin. A stage was designed with precompression (PC) rotor airfoil sections. These airfoils had suction surfaces contoured to generate a field of weak shocks upstream of the channel entrance shock, thereby reducing its incident Mach number and loss. This concept of blade design is discussed in reference 2. The design was fabricated and tested,

and the tests showed that the design was marginally successful in attaining design goals. At design speed and pressure ratio (2.285), flow was 99 percent of the design value; adiabatic efficiency was 0.818 compared to the design goal of 0.84; and stall margin was 2.7% (ref. 3) which is considered inadequate. Performance deficiencies were due mainly to lower-than-design work input at the rotor tip and to higher-than-design rotor losses in the region of the partspan shroud.

A new program has been initiated to correct the deficiencies noted during the original program. As part of the new program, the rotor was redesigned using multiple-circular-arc (MCA) airfoil sections instead of the original PC airfoils. The choice of MCA airfoils was based on the success of this type of airfoil in high Mach number NASA fans (ref. 1 and 4) and in Pratt & Whitney Aircraft fan stages. The extensive experience with MCA blades was applied to solve the problems that led to the deficiencies in the performance of the original rotor. Although the rotor was redesigned, the original stator has been retained because no improvement in performance was predicted for a redesigned stator. The data from the tests of the original stator (ref. 3) showed an adequate range of low-loss incidence angles and loss levels that are in good agreement with design predictions.

Testing of the original design has demonstrated that the original blade design was structurally adequate. Therefore, the only structural changes made to the blade were those necessitated by the substitution of a MCA blade shape for the original PC shape. In addition to the blade changes, an oil-damped forward bearing-system is to be utilized to improve the tolerance of the rotor-shafting assembly to imbalance.

The scope of the present work is to redesign and fabricate a rotor to replace the original rotor and to document performance of the stage with this redesigned rotor. Results of this test will extend the range of design data on MCA airfoils to Mach numbers above 1.8.

This report presents the detailed aerodynamic and mechanical redesign of the 548.6 m/sec [1800 ft/sec] tip speed rotor with MCA airfoil sections. It also presents an analysis of critical speeds, showing reasons for the selection of an oil-damped bearing in the test rig.

All symbols used in this report are defined in Appendix A.

AERODYNAMIC DESIGN

The 548.6 m/sec [1800 ft/sec] tip-speed rotor has been redesigned to improve efficiency and stall margin. Pressure ratio and flow goals are the same as for the original design. Predicted overall performance parameters for the redesigned rotor and the stage are listed in Table I.

The redesign has made compatible with the existing flowpath (Figure 1) and stator. The basic stage configuration was a hub-tip ratio of 0.5 at the rotor inlet, a rotor aspect ratio of 2.87, and a stator aspect ratio of 2.23; and inlet-guide-vanes are not used. Within these constraints, an optimum combination of efficiency and stall margin was sought through refinements to the vector diagram design and the use of MCA airfoils. Stator losses used in the redesign were taken from tests with the original rotor. Stator-inlet flow angles predicted for the redesigned rotor are within the demonstrated range of low-loss incidence angles.

TABLE I – PREDICTED OVERALL PERFORMANCE PARAMETERS OF THE REDESIGNED ROTOR AND STAGE

$^{1}W\sqrt{\theta}/\delta$	78.8 kg/sec [173.8 lbm/sec]
$^{2}W\sqrt{\theta}/\delta$ annulus	188.8 kg/sec-m^2 [38.7 lbm/sec-ft^2]
η_{ad} rotor	0.870
P/P rotor	2.34
η_{ad} stage	0.837
P/P stage	2.285

Note: 1. corrected flow.
2. specific flow.

Tip shock patterns from the original rotor show evidence of precompression, but the patterns do not conform to that which was assumed for the PC airfoil design. The design and test shock-patterns are shown in Figure 2. The test data shows a complex test pattern in which the channel entrance shock is followed by reacceleration and a channel exit shock. In contrast the model assumed subsonic flow downstream of the channel entrance shock. The test shock-pattern has no obvious advantage over patterns that have been obtained in tests of MCA airfoil rotors, an example of which is shown in Figure 3. The MCA airfoil pattern also shows precompression upstream of the channel entrance shock and that the shock is oblique and not normal as often assumed for MCA airfoil sections – the greater detail shown in the PC pattern is due to better data accuracy than was obtained in the earlier MCA rotor test. The oblique shock at the channel entrance of the MCA airfoil sections and the precompression ahead of this shock achieve the design goals of the PC airfoil sections. Data from the MCA tests indicate that losses should be slightly lower than predicted for the original PC rotor.

A partspan shroud is located at about 65 percent span and has a thickness of about three percent of the span at the rotor trailing edge. Local choking due to shroud blockage in the original rotor is believed to have been partly responsible for the high shroud-losses. In the redesigned rotor, extra throat area is provided in the channels between blades to compensate for this blockage. As a result the shroud-related loss, which extends over about half of the span of the original rotor, should be reduced in spanwise extent in the redesigned rotor.

ROTOR LOSS ESTIMATES

Rotor losses were estimated using a correlation of test losses from high Mach number rotors having MCA airfoils. Short extrapolations from data gave loss estimates corresponding to the redesigned rotor Mach numbers. The radial profile of estimated loss coefficients is given in Figure 4; the figure also provides the predicted and test losses of the original rotor. Design loss values were attained at the tip of the original rotor except near stall, hub losses were lower than design, and losses in the region of the partspan shroud were much larger than design. Despite the change from the PC airfoils to the more conventional MCA airfoils, the predicted losses for the redesign rotor are lower than those that had been predicted for the original rotor.

The radial profile of loss coefficient for the redesigned rotor shown in Figure 4 has not been modified to include partspan shroud loss. The design losses shown in the figure give an adiabatic efficiency of 0.884 for the redesigned rotor and 0.868 for the original rotor. The corresponding radial profile of rotor efficiency (without shroud loss) is given in Figure 5. Data from references 3 and 5 indicates that partspan shroud loss will decrease rotor adiabatic efficiency by 0.014. The effect of this shroud loss is accounted for by treating its wake as a blockage and by subtracting the estimated shroud efficiency penalty from the overall efficiency calculated without shroud effect. The resulting overall adiabatic efficiency predicted for the rotor is 0.870. The addition of the stator loss determined in tests with the original rotor (ref. 3) results in a predicted stage efficiency of 0.837. All values of rotor-overall and stage-overall efficiency given in this report include the compensation for partspan shroud loss.

RADIAL PROFILE OF PRESSURE RATIO

A study was made of the effect on stall margin and efficiency of variations in the spanwise distributions of rotor exit total pressure. Mass-flow averaged rotor pressure ratio was held constant at 2.34 for all pressure ratio profiles. A streamline analysis computer program was used to calculate overall and blade-element performance parameters. Pressure ratio profiles affected efficiency primarily by radially redistributing the flow while loss profiles remained nearly constant. Changes in stall margin were caused by a combination of differences in design point loadings (D factors) and different trends of increasing loading as a function of decreasing flow. Loading trends at design speed were calculated using the streamline program run with the design point radial distributions of rotor and stator exit air angles and losses and with decreasing inlet flows. Stalls are predicted when the calculated D factors exceed the values at which stall occurred in tests with the original rotor (ref. 3). A rotor hub (10 percent span) D factor limit of 0.65 was obtained from hub-radial distortion test data, and a rotor tip (90 percent span) D factor limit of 0.52 was obtained from uniform-inlet and tip-radial distortion test data. The stator D factor limit of 0.65 in the region between 10 percent and 90 percent of span was obtained from tests of stages with similar stators. Excessive rotor loadings, as calculated by the streamline program, determined the estimated stall points for all of the pressure profiles investigated.

Results of the pressure profile study indicate that variations from a flat profile offer only minor gains in pressure ratio or efficiency. The different pressure profiles and the predicted effects on stall margin and efficiency are presented in Figure 6. The flat profile with the locally high pressure at the hub (Figure 6f) was selected on the basis of near optimum stall margin and efficiency and adaptability to existing platform and attachment designs. This profile is compared in Figure 7 to the measured profile for the original rotor; a similarity near the hub can be seen. The slight benefits calculated for the flat profile are not considered large enough to justify redesigning the platform and attachment. Predicted stall margin is seven percent with the selected pressure profile. A sine wave shaped profile gave the highest calculated efficiency, but stall margin was inadequate.

VECTOR DIAGRAMS

Radial profiles of meridional velocity for the rotor inlet and exit are presented in Figure 8. The low velocity near the endwall is the result of the streamline curvature effects caused by the steep wall-slopes required to provide the desired annulus convergences. The profiles with the original and redesigned rotors are similar, as shown in Figure 8.

The methods used to account for partspan shroud blockage for the original and redesigned configurations are different. Because of this, the redesigned configuration has a lower predicted average velocity at the rotor inlet (also at the rotor exit). In the original design the effective flow area was reduced to account for the shroud blockage, while for the redesigned configuration extra area is provided in the blade channel in the region of the shroud to compensate for the blockage. In the redesign calculations, blockage values to account for endwall boundary layers and to account for the shroud wake at the rotor exit and stator inlet stations are based on data from tests with the original rotor (ref. 3). Blockages are applied uniformly across the span at each axial location. Flowpath blockages at the blade-edge locations are listed in Table II.

TABLE II – BLOCKAGES IN STREAMLINE CALCULATIONS FOR REDESIGNED ROTOR (Percent of Annulus Area)

Axial Location	Wall Boundary Layers	Partspan Shroud Wake	Total Blockage
Rotor Inlet	2.0	0	2.0
Rotor Exit/ Stator Inlet	2.5	3.2	5.7
Stator Exit	4.0	0	4.0

Meridional velocity at the rotor exit is slightly flatter for the redesign than for the original design (Figure 8). Higher velocities near endwalls of the redesigned rotor resulted from lower estimated endwall losses. Lower midspan velocities resulted from higher flow through endwall regions and from a higher estimated rotor efficiency which reduced corrected flow at the rotor exit.

Radial profiles of relative Mach number are presented in Figure 9. The inlet Mach number is supersonic from 9.5 percent span from the hub, reaching a value of 1.773 at the tip. Rotor exit flow is subsonic throughout the span. The Mach number profiles are nearly identical to those of the original rotor design, also shown in Figure 9.

Relative air angles for the rotor inlet and exit are plotted as functions of span in Figure 10. Data from the near-design test point given in Figures 9 and 10 show test values of relative Mach numbers and flow angles at design speed, near-design flow, and near-design levels of loading. Tip-region exit angles are not faired as in the original design in which the steep grad-

ient in predicted loss near the tip caused a sharp change in the exit relative air angle (ref. 2). The flow deflection angle at the hub is 45 degrees, tapering to zero degrees at the tip where work is obtained without turning (in the relative frame) by diffusing the meridional flow. The exit relative air angle at the hub does not pass the axial direction.

Design velocity vector data along streamlines at the rotor leading and trailing edges are tabulated in Appendix B.

BLADE ELEMENT LOADINGS

High solidity was used to control loadings. Rotor solidity, shown versus span in Figure 11, is almost exactly the same as used in the original rotor design. Rotor blade-element loadings are approximately the same for the original and redesign, as shown by the radial profiles of D factors for the two rotors (Figure 12). The redesigned rotor has lower D factors in end regions because estimated losses are lower than for the original rotor.

REDESIGNED ROTOR COMPATIBILITY WITH EXISTING STATOR

One of the requirements of the redesign rotor is that it be compatible with the existing stator. Predicted inlet air angles for the stator were checked with respect to the range of low loss inlet flow angles determined in tests with the original rotor (Figure 13). This region is defined as the range of stator inlet flow angles in which loss coefficient ($\bar{\omega}$) is less than 0.05 plus $\bar{\omega}$ min. The test data was obtained at a stator stagger angle setting of 2.5 degrees open (direction of increasing incidence); however, the angles in Figure 13 were adjusted to show the low-loss range at its nominal stagger setting. The stator is expected to be near optimum incidence at design point in its nominal stagger setting.

ROTOR BLADE DESIGN

The rotor was designed to produce an overall total pressure ratio of 2.34, distributed radially as shown in Figure 7, at a tip speed of 548.6 m/sec [1800 ft/sec]. There are 38 rotor blades, and the aspect ratio of the blades is 2.87 (based on average blade length and axially projected hub chord).

Multiple Circular Arc Airfoil Definition

Multiple-circular-arc airfoil sections are defined by total chord, front chord, maximum thickness, chordwise location of maximum thickness, total camber, front camber, and leading and trailing edge radii, as shown in Figure 14. Front chord length for each airfoil is equal to the distance from the leading edge to a point on the suction surface where a normal shock at the channel entrance would impinge.

In general, airfoil thicknesses were set at the minimum values capable of satisfying mechanical design criteria. Chordwise locations of maximum thickness were set to blend smoothly from wedge shaped thickness distributions in front at the tip, to convex thickness distributions at the hub. Stagger and camber of front sections controlled both the incidence angle to the relative inlet flow and the throat area in the channel between blades. Rear suction camber provided the necessary trailing edge metal angle to give the desired exit relative flow angle.

Aerodynamic airfoil sections were designed on conical surfaces which approximate stream surfaces of revolution.

Incidence and Deviation Angles

Incidence angles for sections whose inlet relative Mach number (M'_1) exceed 1.0 were chosen at a location termed the a′ point which is a point on the suction surface halfway between the leading edge and the point from which a Mach wave emanates that meets the leading edge of the following blade. This incidence alignment technique for supersonic flow is explained in reference 6. Incidence at the a′ point, together with entrance-region flow alignment and channel area considerations, determined leading edge incidence angle. For most sections with M_1' greater than 1.0, incidence was set approximately 2.0 degrees to the blade suction surface at a′; the 2.0 degrees is intended to account for blockage at the blade leading edge, development of the suction surface boundary layer, and bow-wave loss. For sections where M_1' was only slightly greater than 1.0, higher values of incidence to the a′ point were required to provide adequate flow area while maintaining a smooth distribution of leading edge incidence. Incidence angles at the a′ point are locally higher in the region of the partspan shroud where blade passage area was increased to compensate for shroud blockage. Incidence angles for subsonic sections were set at the leading edge in accordance with minimum loss data from previous experience. Incidence angles to the suction surface are plotted as a function of span in Figure 15. The incidence angle to the a′ point is also shown for the supersonic portion of the span.

Deviation angles were calculated using a modification of the P&WA cascade method. The modification is based on data from tests of the original rotor (ref. 3) and from many MCA rotor tests. The original-rotor data is weighted heavily in this modification. Figure 16 shows the deviation angles versus span, and the difference in deviation angles as calculated using Carter's rule is shown in Figure 17. Rotor inlet and exit metal angles and aerodynamic-section conical surfaces are presented in Figure 18.

Choke Margin and Starting Criteria

Camber of each airfoil section was distributed to provide a minimum critical-area ratio (A/A*) of 1.04 in the channel throat between blades. Throat area was sized to provide adequate throat area to achieve design flow while limiting the growth of separated boundary layers on blade surfaces. Experience with MCA rotor blades (ref. 1 & 4) shows that the optimum value of A/A* is approximately 1.04. Distribution of (A/A*) through blade channels are shown in Figure 19 for several percents of span. To compute these flow area ratios for each streamline, actual area A was calculated by correcting the local channel widths between adjacent blades to account for streamtube annulus area convergence or divergence. Critical area A* at these locations was determined by modifying the value at the leading edge to account for losses and changes of radius. The loss calculated for each streamline was distributed in the following manner: 1) no loss was assumed from the leading edge to the location of the first covered section of the blade (Figure 14b); 2) a normal shock was assumed to be situated at the first covered section where the Mach number immediately upstream of the shock is determined by isentropic relationships that satisfy continuity at the channel entrance; and 3) the profile loss (total loss minus shock loss) was applied linearly from a value of zero at the channel entrance to the full value at the trailing edge. Additional throat area was designed into the region of the partspan shroud to compensate for its blockage.

Throat area was controlled primarily by the front-section camber. Front camber angles are plotted versus span in Figure 20. Chordwise distributions of camber are indicated by the chord-camber parameter, $C \sin (\phi_{Ef}/2)/C_f \sin (\phi_E/2)$, which is the airfoil average meanline radius of curvature divided by the front section meanline radius of curvature. This parameter equals 1.0 for standard double-circular-arc (DCA) airfoils and becomes smaller as the front section is uncambered. Figure 21 shows that all airfoil sections have uncambered front sections relative to DCA airfoils. Compression fields are generated ahead of the channel entrance shock by those sections which operate with supersonic inlet flow and have less suction surface curvature upstream of the first captured Mach wave than free-stream flow turning. The outer 55 percent of the span was designed to have this type of precompression.

The minimum (A/A^*) values for the redesigned rotor exceed those of the original rotor at all spanwise locations, as shown in Figure 22. Since oblique shocks were indicated for the original rotor and since maximum flow at design speed exceeded design flow, the redesigned rotor should have adequate choke margin to start an oblique shock system. The shock can become oblique where the combination of relative inlet Mach number and air deflection angle of the pressure surface at the leading edge allows attachment. Where this deflection angle is too large in relation to the Mach number, a detached normal shock is expected. On this basis, the rotor can operate with attached oblique shocks over the outer 63 percent of span at design speed and flow.

The speed at which oblique shocks could start was estimated for three spanwise positions (71 percent, 82 percent, and 93 percent of span from the hub) using the method outlined in reference 7. The relative air angle of the inlet is assumed to be constant as speed is reduced and the point noted at which flow downstream of a normal shock would choke the blade passage. Figure 23a shows the relative inlet Mach numbers versus percent speed for the three spanwise positions. Figure 23b compares the Mach numbers immediately downstream of the shock to the Mach number for which the passage throat is choked, for each spanwise position. Starting occurs first at the tip and progresses down the blade as speed is increased. The spanwise extent of the blade predicted to be capable of having started-flow is shown in Figure 24 as a function of speed. Extrapolation of the data in this figure indicates that starting can begin at about 85 percent of design speed and that all sections designed to have oblique shocks (outboard of 37 percent span) can be started at approximately 98 percent speed.

Rotor Blade Geometry

Rotor blade airfoil aerodynamic sections on conical surfaces are specified in Appendix C. Figure 25 provides a polar representation of a mean camber-line and shows the relationship between surface cone angle and the angles which define the airfoil meanline. For manufacturing purposes, the airfoil sections were redefined on planes normal to a radial stacking line. Each manufacturing section is defined by surface coordinates, coordinates of the stacking line, the angle from the chord line to the axial direction, airfoil edge radii, and the radius from the rotor centerline. Airfoil manufacturing coordinates are given in Appendix D, and the MCA airfoil design parameters are shown schematically in Figure 26.

Aerodynamic-Mechanical Design Interface

The redesigned rotor blade, an MCA airfoil from hub to tip, is designed to have mechanical properties similar to the original rotor PC blade which demonstrated good mechanical performance. As the design progressed, mechanical properties were calculated for each significant aerodynamic change and results or constraints were fed back into the aerodynamic design. In this manner, aerodynamic and mechanical design goals were achieved simultaneously.

The first blade design iterations had airfoil sections with the same cross-section areas as the original blades. To achieve the desired mechanical properties with the change in airfoil section type, some significant changes in airfoil thicknesses were required. Figure 27 shows that the maximum-thickness to chord ratio is higher near the hub and lower near the tip for the redesigned rotor. A reduction in thickness at the tip was made possible by a more favorable chordwise distribution of thickness. The chordwise locations of maximum thickness for the original and redesigned rotor blades are plotted as a function of span in Figure 28. Aerodynamic chord lengths (and solidities) were not changed significantly from original-design values (Figure 29).

STRUCTURAL AND VIBRATION ANALYSIS

Mechanical design of the redesigned rotor blade was guided by experience with the original rotor which had demonstrated good mechanical and aeroelastic behavior. The mechanical design included an investigation of rotor airfoil steady-state and vibrational stresses and flutter parameters. Natural modes of vibration of the rotor system were calculated and rotor-frame critical speed and forced response analyses were performed to determine the dynamic characteristics of the fan rig. Design limits were determined by recalculating properties of the original rotor by means of the latest proven design method – a different method than used in the design of the original rotor. Properties of the redesigned rotor were kept within those achieved during tests of the original rotor, both sets of properties having been calculated the same way.

Due to a slight reduction in blade weight, the attachment and disk stresses are slightly lower than those for the original rotor. Information on the original mechanical design, including the disk, blade attachment, and the stator, is given in reference 2.

ROTOR BLADE STRESSES

Combined centrifugal pull and untwist rotor blade stresses were calculated for the redesigned airfoil at 105 percent of design speed. The blade material is AMS 4972A titanium bar stock, the same material used in the original design. The finite element analysis program, NASTRAN, was used to perform this anslysis. Gas bending stresses with centrifugal restorations were calculated at design speed for various tangential tilts of the blade. Airfoil stresses were minimized for the combination of load and no load conditions. The selected tangential tilt is 0.00121m [0.050 in.] which results in a maximum tensile bending stress due to gas loads and tilt of 3.79×10^7 N/m^2 [5500 lbf/in.^{2}] at 12,500 rpm. Table III presents a comparison of local concentrated stress levels for the original airfoil and the redesign airfoil. The table shows that the maximum stress is lower for the redesigned airfoil than for the original airfoil which had been tested successfully. The resultant low-cycle-fatigue (LCF) life for the redesigned blade is adequate for experimental rig operation. The allowable concentrated local stress for an LCF life of 1000 cycles is 122.6×10^7 N/m^2 [178×10^3 lbf/in.^{2}].

TABLE III – SUMMARY OF AIRFOIL MAXIMUM LOCAL CONCENTRATED STRESSES FOR THE REDESIGNED AIRFOIL

	Redesigned Airfoil	Original Airfoil
Maximum Rotational Speed	13,115 rpm	13,115 rpm
Max. Nominal Local Stress at Airfoil Root	70.3×10^7 N/m^2 [102×10^3 lbf/in.^{2}]	104.8×10^7 N/m^2 [152×10^3 lbf/in.^{2}]
Max. Concentrated Local Stress Airfoil Root	97.2×10^7 N/m^2 [141×10^3 lbf/in.^{2}]	133.1×10^7 N/m^2 [193×10^3 lbf/in.^{2}]
LCF Life at Airfoil Root	2,700 cycles	600 cycles
Max. Nominal Local Stress Below the Shroud	100.0×10^7 N/m^2 [145×10^3 lbf/in.^{2}]	60.7×10^7 N/m^2 [88×10^3 lbf/in.^{2}]
Max. Concentrated Local Stress Below the Shroud	110.4×10^7 N/m^2 [160×10^3 lbf/in.^{2}]	65.2×10^7 N/m^2 [95×10^3 lbf/in.^{2}]
LCF Life for Airfoil Below the Shroud	1,800 cycles	10,000 cycles

The locations of maximum steady-state and vibratory stresses are shown in Figure 30. A modified Goodman diagram (Figure 31) based on the average steady stress indicates that the maximum allowable vibratory stress is 7.59×10^7 N/m^2 [11,000 lbf/in.^{2}]. The maximum average steady stress used with the Goodman diagram is 52.4×10^7 N/m^2 [76.0×10^3 lbf/m^2] which is the average of the local concentrated stresses on the pressure and suction surfaces of the blade. During testing, a vibratory stress limit of 6.89×10^7 N/m^2 [10,000 lbf/in.^{2}] will be imposed. Since no low order resonances are expected in the high speed operating range, the actual vibratory stress levels that will be encountered during testing should be less than the 6.89×10^7 N/m^2 [10,000 lbf/in.^{2}] limit set as part of the test procedures.

ROTOR BLADE RESONANCES

Coupled mode blade-disk resonances which might be excited in the operating range have been avoided by the proper choice of shroud location, shroud angle, and blade material. Low order excitation from circumferential distortion or other possible inlet pressure variations will not excite the system because the blade and disk have been designed to insure that natural modes for the system will not occur at frequencies close to one, two, or three excitations per revolution (1E, 2E, or 3E) during high-speed operation. The blade-disk coupled mode resonance diagram is shown in Figure 32. The first bending mode 3E frequency margin is more than the required 5% at 105 percent of design speed. Blade strain-gages will indicate any resonant conditions that exist, and test speeds can be adjusted accordingly to avoid operation at these resonant conditions.

Rotor blade tip chordwise bending modes are of great concern with the thin tip sections of modern fan blades. Excitations from inlet struts and stator vanes upstream and downstream of the rotor can interact with the natural frequencies of these tip chordwise modes to produce high dynamic stresses. Figure 33 shows the resonance diagram for the tip chordwise bending modes. The vane passing resonance (60E) does not occur in the operating range for the first and second tip chordwise bending modes. A 10E resonance, which could be excited by the ten inlet case struts, occurs in the high speed operating range. But no evidence of this excitation was found in stress records of the original fan stage which used the same inlet case; a 10E resonance was also predicted high in the operating range of the original stage.

ROTOR BLADE FLUTTER

Flutter is a self-excited, self-sustaining vibration which can occur in either a torsional or bending mode or a combination of both. To prevent rotor blade flutter, a partspan shroud is required. Values of the flutter parameters for the blades were calculated at 105 percent of design speed, the operating speed considered most critical in regard to flutter, and these values were compared with correlated test data from previous programs. Two types of flutter are of concern for high tip-speed fans: subsonic torsional stall flutter and supersonic unstalled flutter.

Subsonic tortional stall flutter was correlated with the reduced velocity parameter. The value of this parameter for the redesigned blade is 1.4 which lies within the range of P&WA experience where flutter problems have not been encountered.

Supersonic unstalled flutter occurs when a rotor is operating with a uniform supersonic inlet flow and with an unstalled passage-flow. Correlation for this flutter is based on the assumption that energy generated by unsteady aerodynamic work is absorbed by the fluid (ref. 8). Resistance or susceptability to this type of flutter is assessed in terms of an aerodynamic damping parameter (unsteady-aerodynamic-work/rotor-kinetic-energy). Relatively larger values of this parameter indicate more resistance to flutter and smaller values more susceptability. The values of the aerodynamic damping parameter for the original airfoil and for the redesigned airfoil lie within range of P&WA experience where flutter problems have not been encountered.

PARTSPAN SHROUD

Aerodynamic and structural requirements dictated the size and position of the partspan shroud. The partspan shroud must provide stiffness for adequate vibration margin but should be as thin as possible to minimize penalties in aerodynamic performance. Shroud design parameters and stresses are summarized in Table IV. Bearing stress for the shroud is 4.34×10^7 N/m^2 [6300 $lbf/in.^2$] which is below values tested successfully on P&WA research rigs, e.g., 5.86×10^7 N/m^2 [8500 $lbf/in.^2$]. The shrouds were designed to fit together sufficiently tight to provide adequate damping of vibrations without "shingling". The Z ratio, a measure of the relative stiffnesses of the shroud and adjacent airfoil, is within the realm of successful experience.

TABLE IV – PARTSPAN SHROUD PARAMETERS
(105 Percent of Design Speed)

Spanwise Location	65 percent span from hub
Contact Angle	65 degrees
Z Ratio	1.07
Bearing Stress	4.3×10^7 N/m^2 [6300 lbf/in.^{2}]
Bending Stress	46.6×10^7 N/m^2 [67,500 lbf/in.^{2}]
Thickness	0.00457 m [0.180 in.]

CRITICAL SPEED AND FORCED RESPONSE

A critical-speed analysis of the rotor frame was performed to determine the vibrational characteristics of the fan rig. The analysis employed the spring-mass system shown in Figure 34 and was based on models that include all significant structural members of the rig.

Two critical speeds occur within the rig operating range, at 5642 rpm and 11,983 rpm; and two critical speeds occur at 13,874 rpm and 17,854 rpm, both above the expected maximum operating speed of 13,115 rpm. Mode shapes for these four critical speeds are shown in Figure 35. The modes at 5642 rpm and 11,983 rpm have low values of the total rotor strain energy (0.25% and 1.7%, respectively) and, hence, are of little concern. The mode at 13,874 rpm has significant motion of the fan rotor and has more than 25% of the total strain energy in the rotating components. To determine whether a bearing damper is needed to reduce the vibratory amplitudes of this critical speed mode, a forced response analysis was performed on the system with and without a front bearing damper. This analysis was similar to the critical-speed analysis except that an imbalance was simulated and the resultant vibratory deflections calculated. Deflections were calculated at the rotor plane and at the flexible diaphragm behind the second bearing for an imbalance of 72×10^{-5} kg-m [one oz-in.].

A rotor deflection of 2.54×10^{-4} m [0.010 in.] was calculated for a 72×10^{-5} kg-m [one oz-in.] imbalance at the most sensitive critical speed, dropping to 0.254×10^{-4} m [0.001 in.] with an oil-damper front bearing. The damped bearing was chosen because of the large reduction in sensitivity of the rotor system to imbalance. The rotor assembly will be balanced to less than 3.6×10^{-5} kg-m [0.05 oz-in] imbalance but may reach 18.0×10^{-5} kg-m [0.25 ox-in.] during testing. This would give a maximum deflection of 6.4×10^{-6} m [2.5 10^{-4} in.] at the rotor at 13,874 rpm, well within the tip clearance. Vibration accelerometers and amplitude pickups will be used to monitor rig and drive system vibration during testing.

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Station	Diameter (Meters) I. D.	O. D.	Axial Position (Meters) I. D.	O. D.	Diameter (Inches) I. D.	O. D.	Axial Position (Inches) I. D.	O. D.
1	.3429	.9263	-.1524	-.1524	13.50	36.47	-6.	-6.
2	.3446	.9106	-.1016	-.1016	13.568	35.85	-4.	-4.
3	.3625	.8857	-.0572	-.0572	14.272	34.87	-2.25	-2.25
4	.3886	.8636	-.0254	-.0254	15.300	34.00	-1.	-1.
5 RLE	.4191	.8407	0.	.0090	16.50	33.10	0.	.355
6 RTE	.5182	.8141	.0622	.0471	20.40	32.05	2.45	1.855
7 SLE	.5281	.7971	.0749	.0721	20.79	31.38	2.95	2.84
8 STE	.5636	.7694	.1331	.1356	22.19	30.29	5.24	5.34
9	.5638	.7671	.1651	.1651	22.198	30.20	6.5	6.5

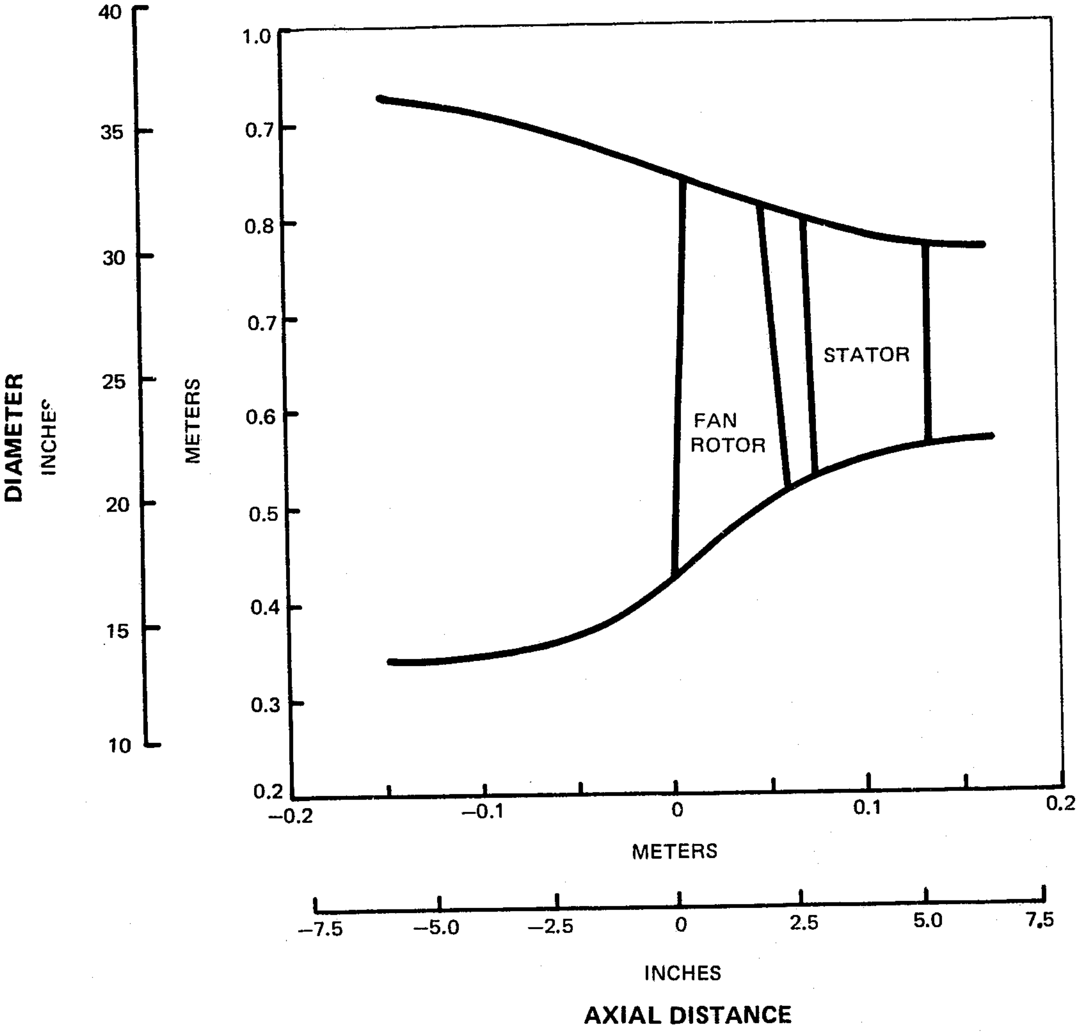
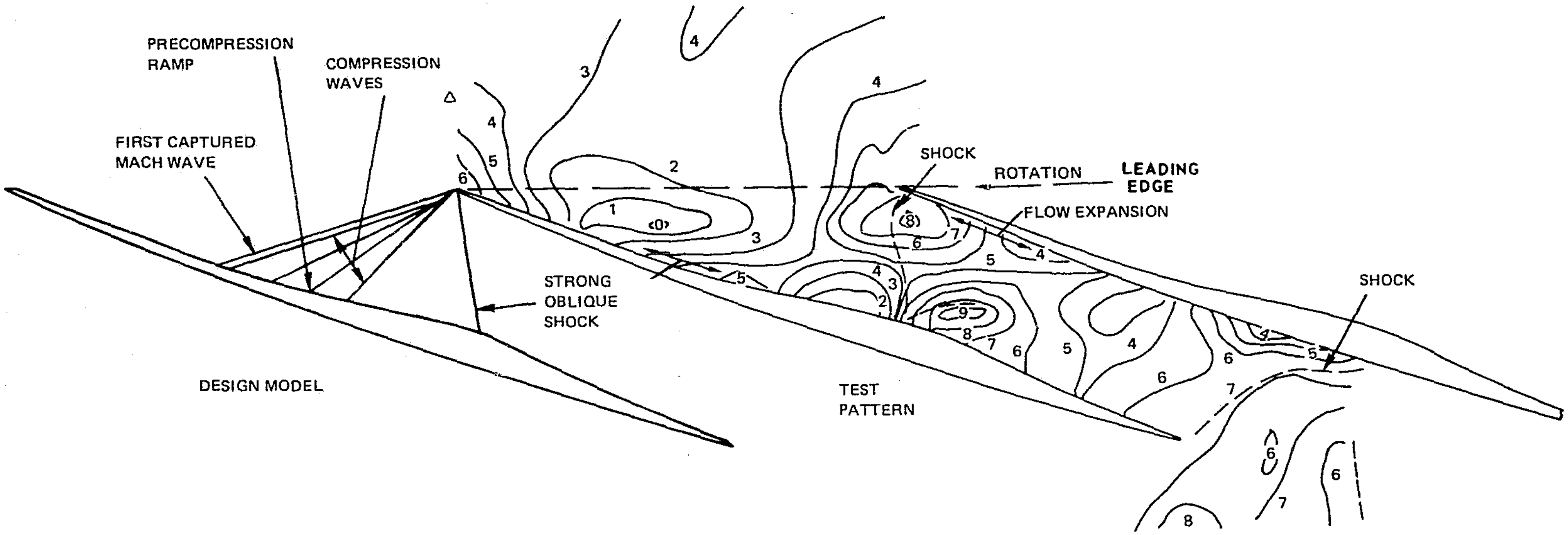
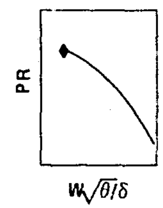


Figure 1 Fan Flowpath With Redesigned Rotor



AVERAGE PRESSURE

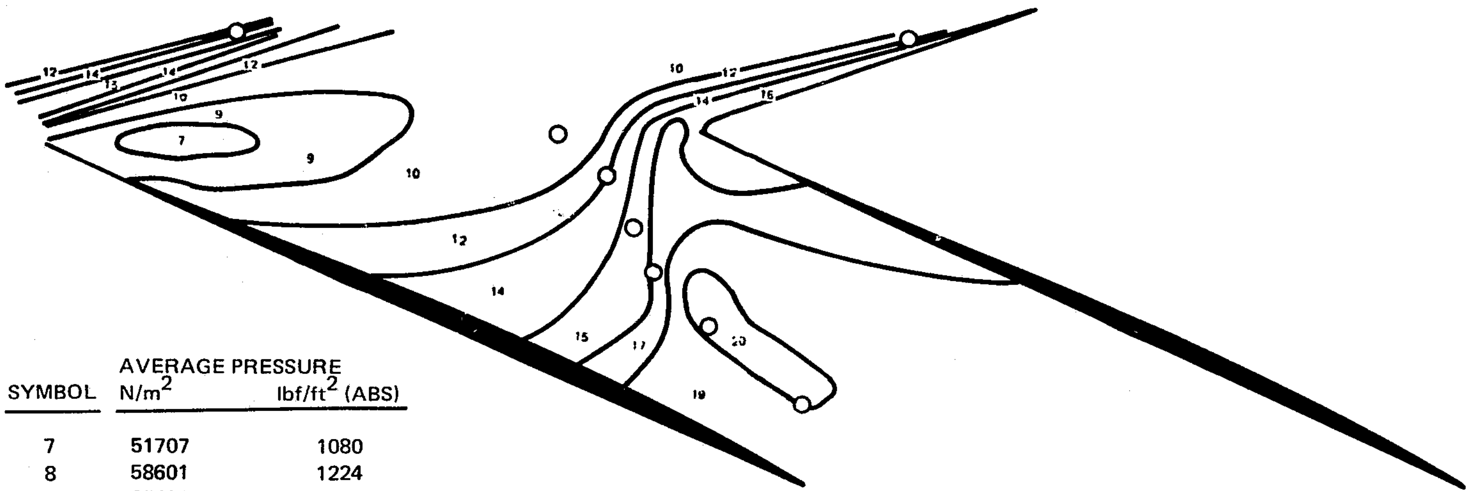
SYMBOL	N/m^2	lbf/ft^2 (ABS)
0	10,871	231.1
1	31,391	665.3
2	51,000	1084.3
3	71,082	1511.3
4	91,163	1938.2
5	111,245	2365.2
6	131,327	2792.2
7	151,408	3219.1
8	171,490	3646.1
9	188,118	3999.6



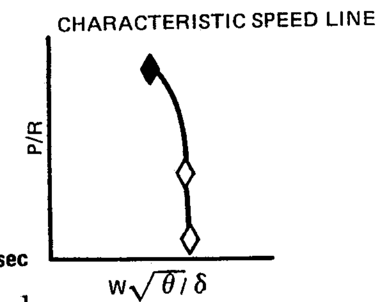
100% SPEED $W\sqrt{\theta}/\delta$ = 78.6 kg/sec (173.2 lbm/sec)

REFERENCE 3

Figure 2 Design Shock Model for PC Airfoil Compared to Test Pattern of Original Rotor



SYMBOL	AVERAGE PRESSURE N/m^2	lbf/ft^2 (ABS)
7	51707	1080
8	58601	1224
9	65495	1368
10	72390	1512
11	19284	1656
12	86178	1800
13	93072	1944
14	99967	2088
15	106861	2232
16	113755	2376
17	120649	2520
18	127544	2664
19	134438	2808
20	141332	2952



105% SPEED $\frac{W\sqrt{\theta}}{\delta}$ = 82.86 kg/sec [182.6 lbm/sec]

REFERENCE 1

Figure 3 Sample Test Shock Pattern for MCA Airfoil

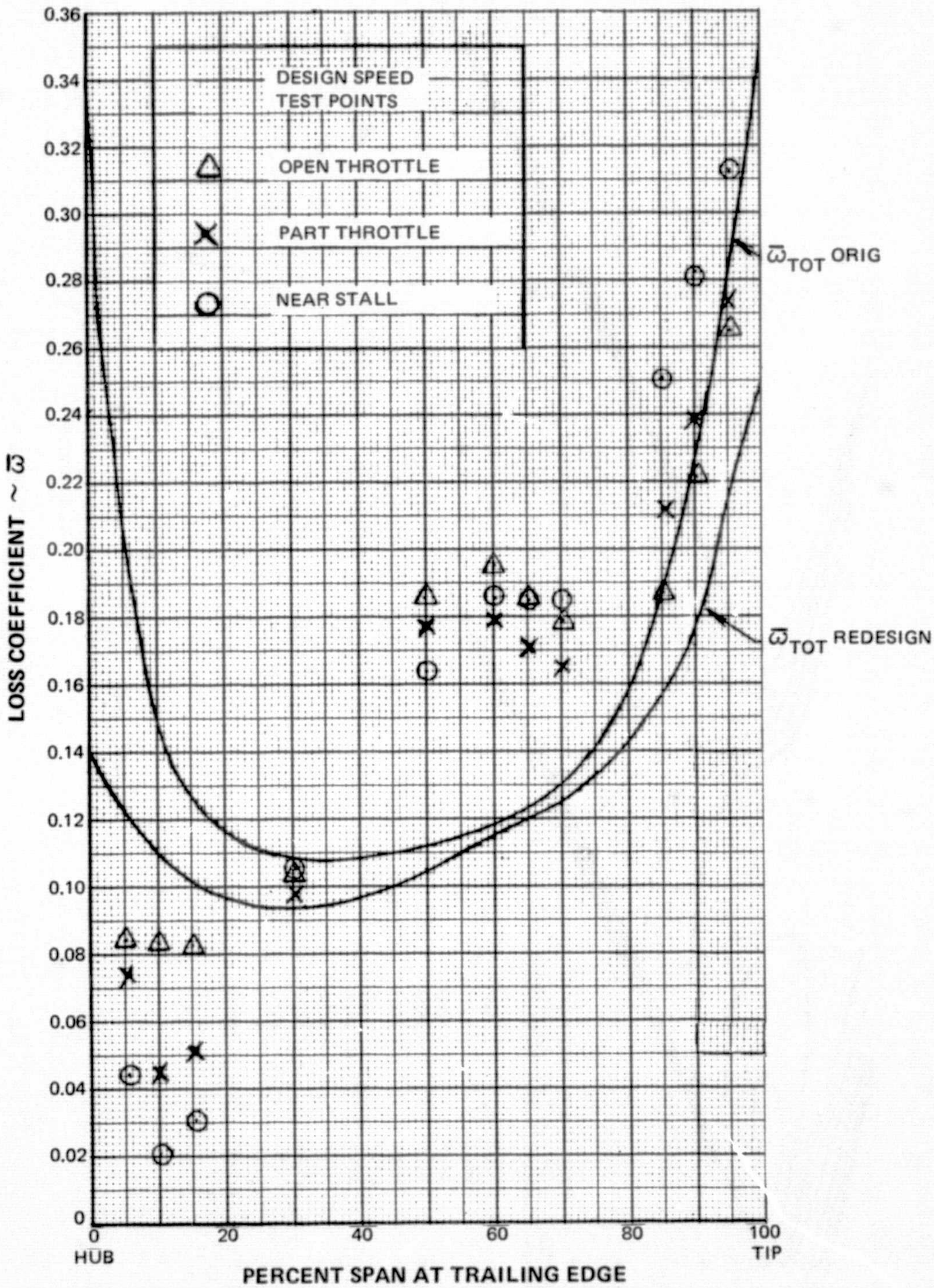


Figure 4 Radial Profile of Rotor Loss Coefficients, Comparing Predicted Profile of Redesigned Rotor With Predicted and Test Profiles of Original Rotor

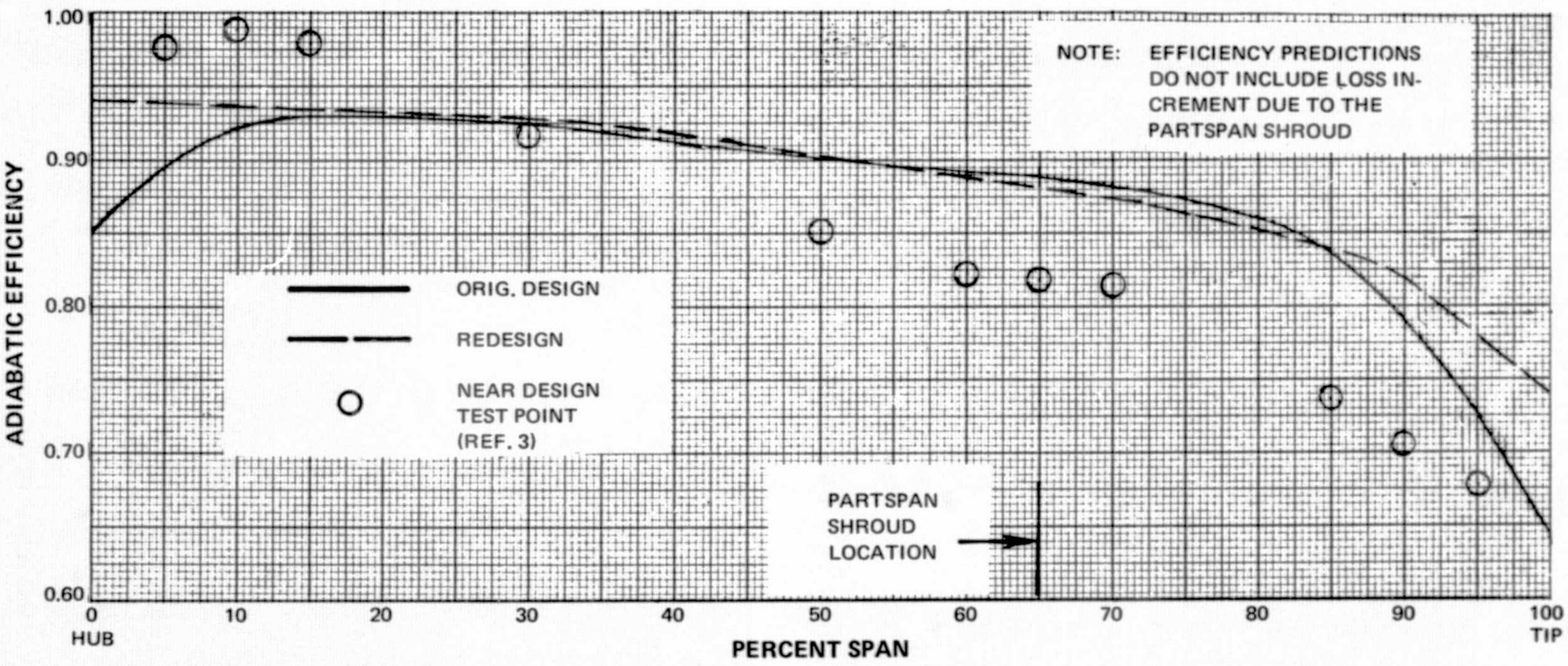


Figure 5 Radial Profile of Rotor Efficiencies, Comparing Predicted Profiles of Redesigned Rotor With Predicted and Test Profiles of Original Rotor

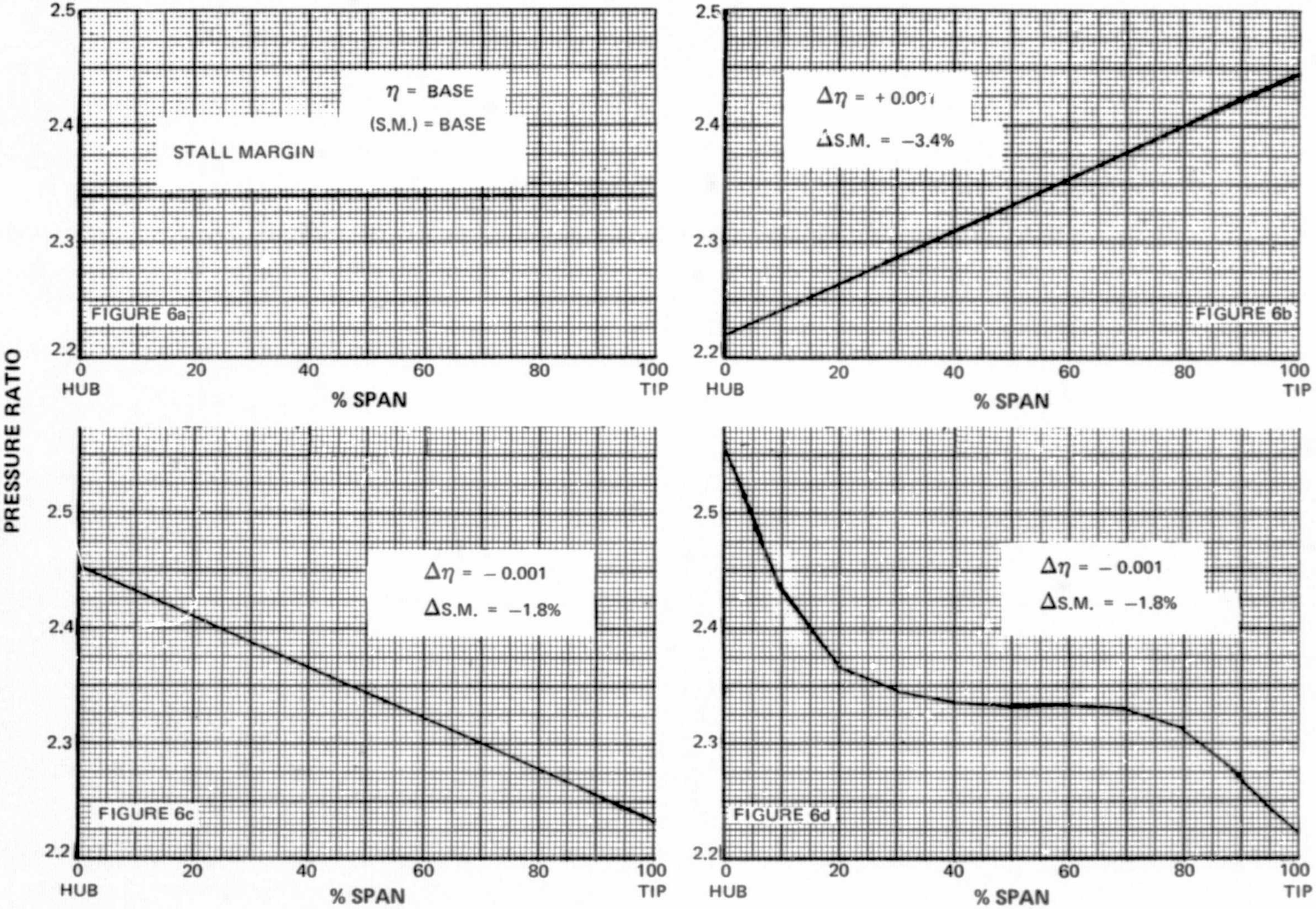
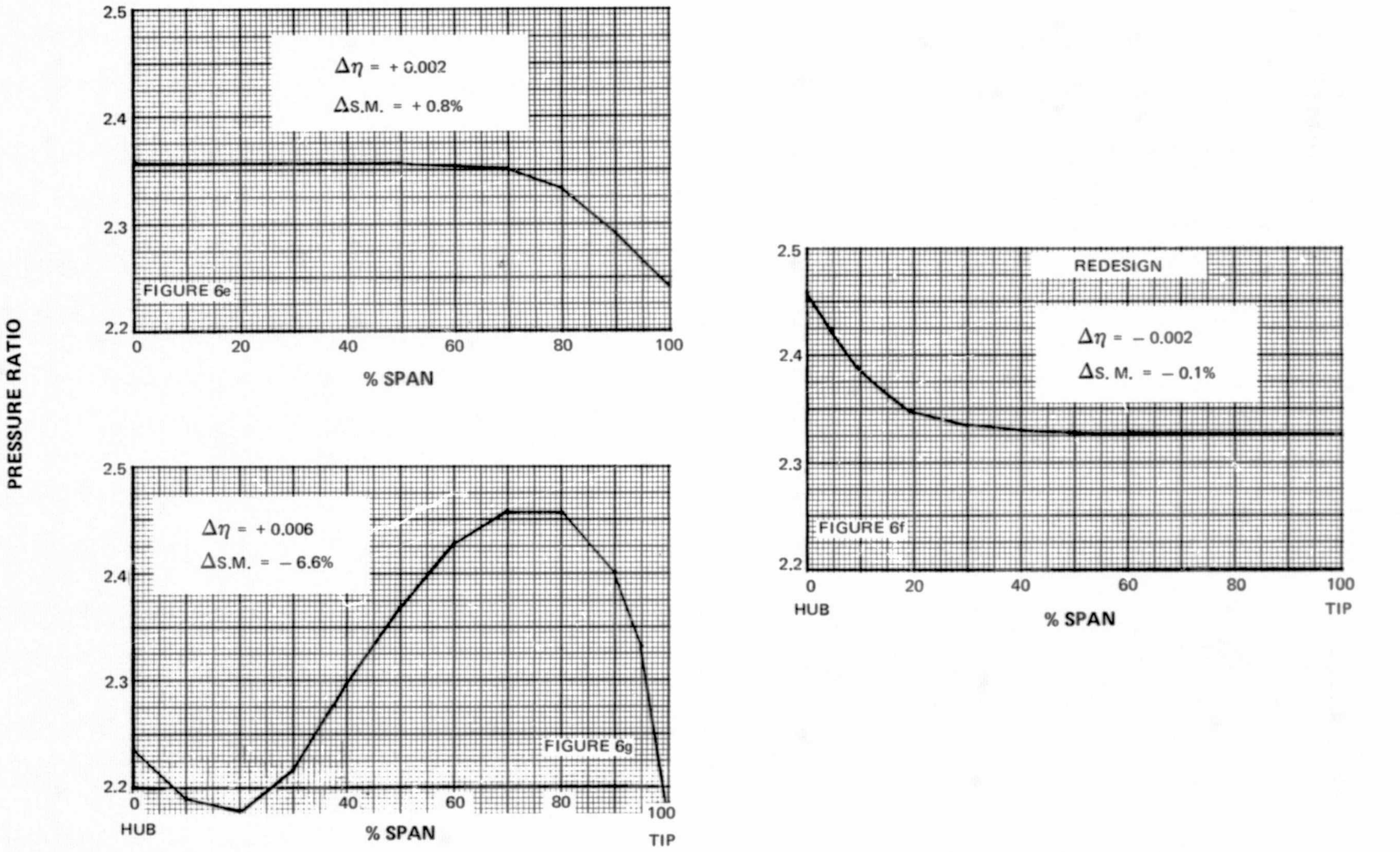


Figure 6 Radial Profiles of Rotor Pressure Ratio and Predicted Effects on Overall Efficiency and Stall Margin



6 (Cont'd) Radial Profiles of Rotor Pressure Ratio and Predicted Effects on Overall Efficiency and Stall Margin

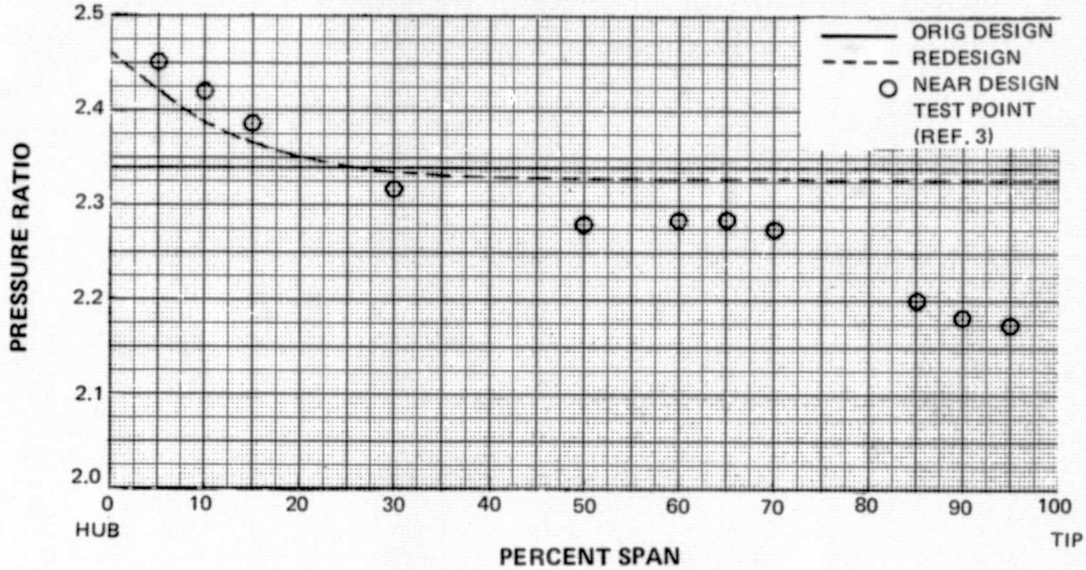


Figure 7 Radial Profiles of Pressure Ratio, Comparing Predicted Profile of the Redesigned Rotor With Predicted and Test Profiles of Original Rotor

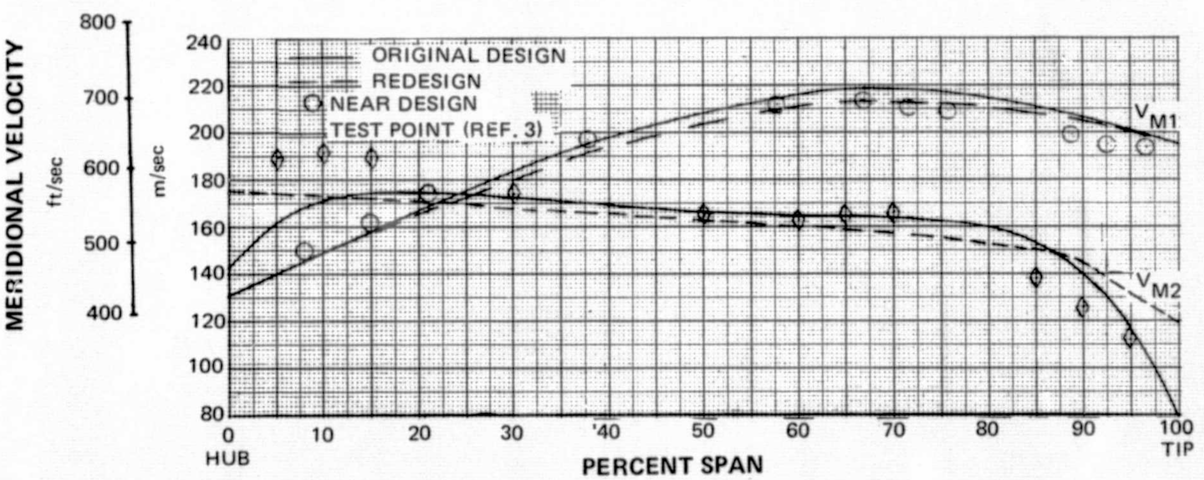


Figure 8 Radial Profiles of Meridional Velocity at Rotor Inlet and Exit, Comparing Design Profiles of the Redesigned Rotor With Design and Test Profiles of Original Rotor

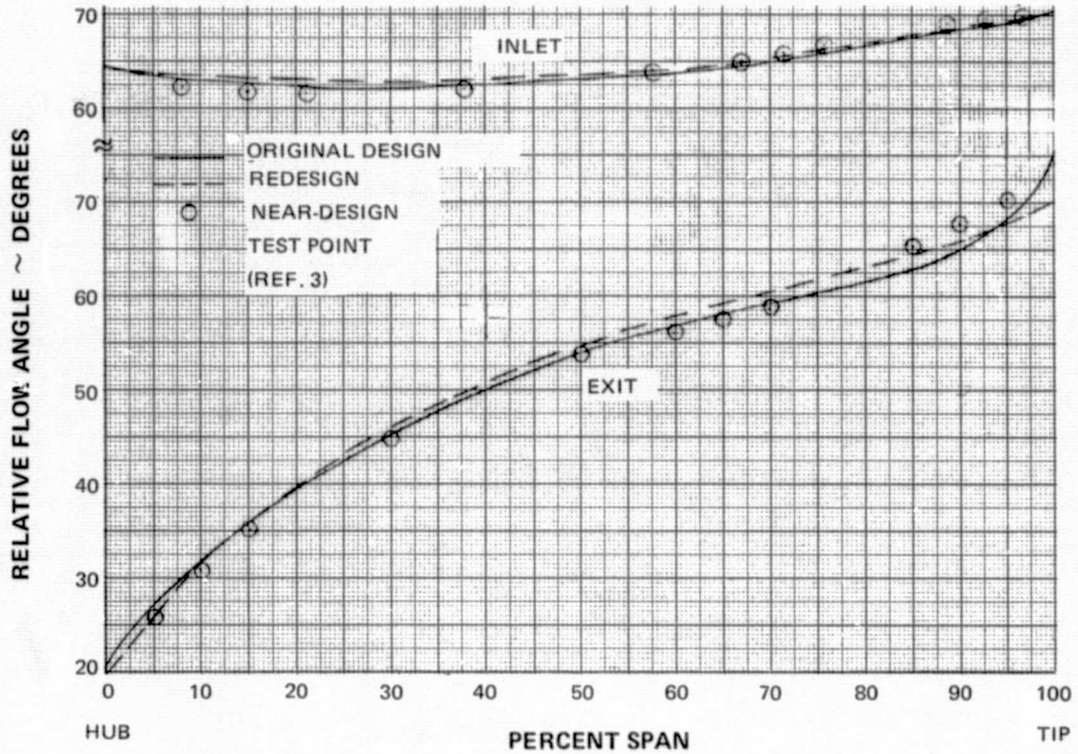


Figure 9 Radial Profiles of Relative Mach Number at Rotor Inlet and Exit Comparing Design Profiles of the Redesigned Rotor With Design and Test Profiles of Original Rotor

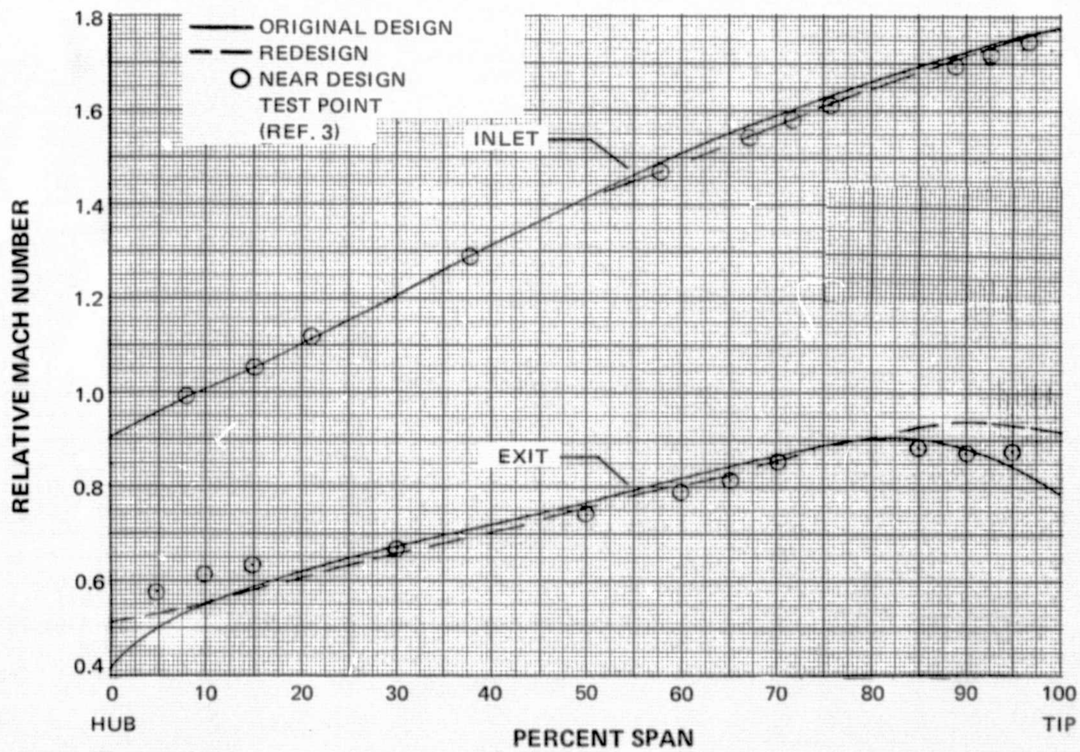


Figure 10 Radial Profiles of Relative Flow-Angle at Rotor Inlet and Exit, Comparing Design Profiles of the Redesigned Rotor With Design and Test Profiles of Original Rotor

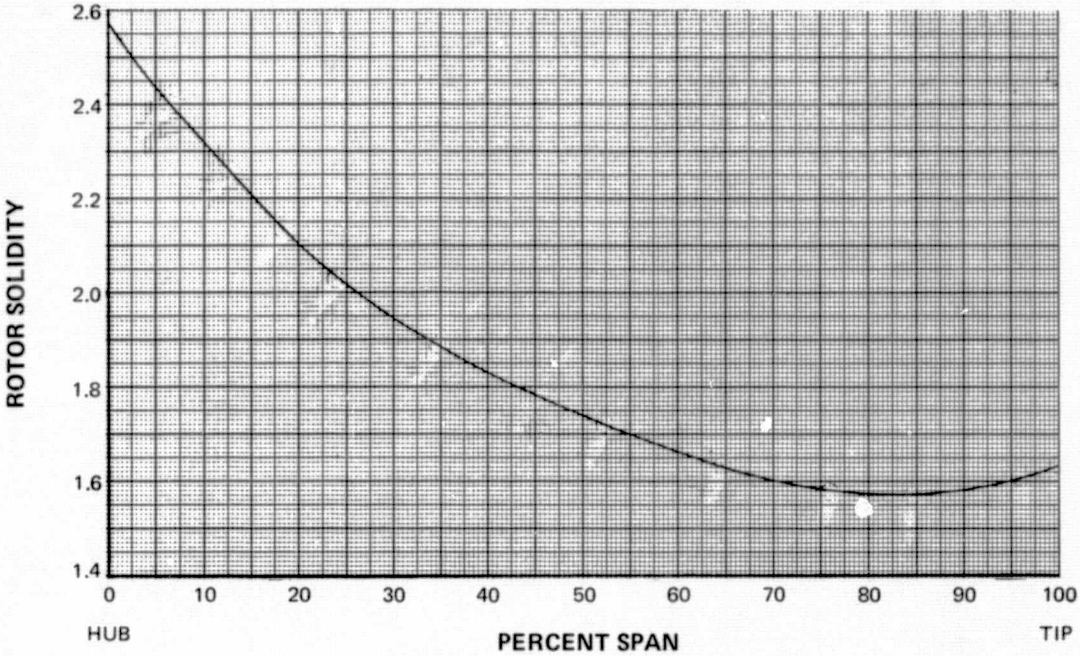


Figure 11 Radial Profile of Rotor Solidity for the Redesigned Rotor

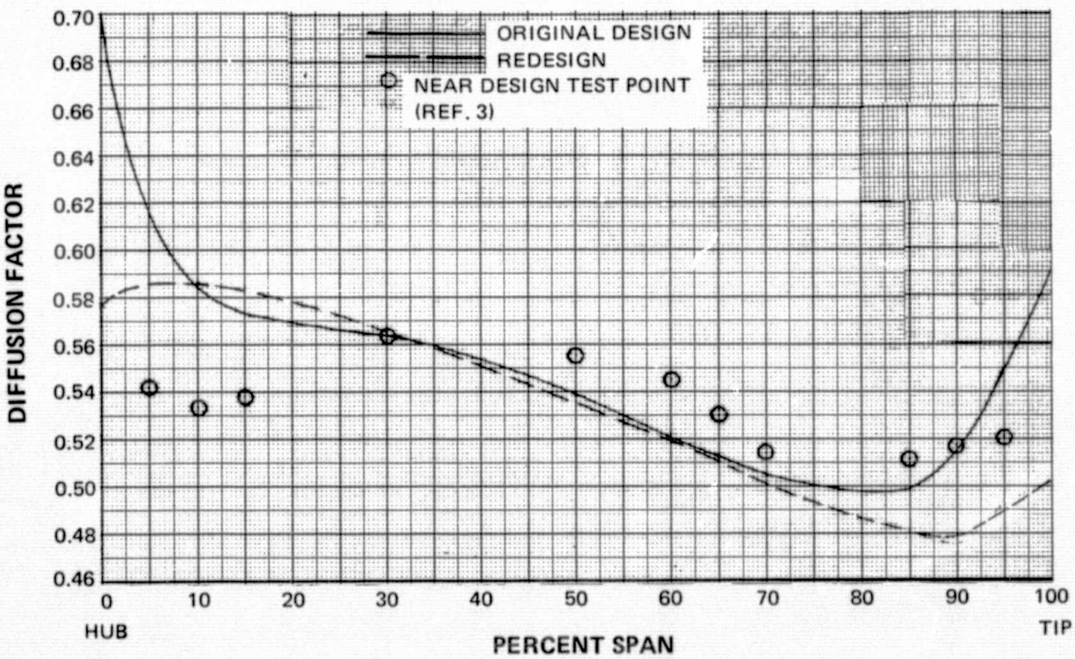


Figure 12 Radial Profile of Diffusion Factor, Comparing Design Profile of the Redesign Rotor With Design and Test Profiles of Original Rotor

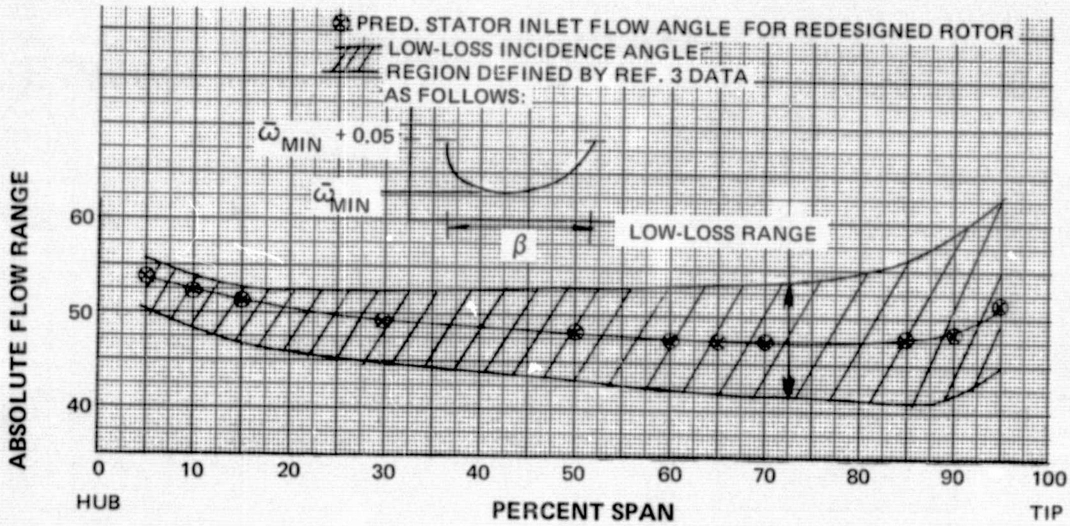


Figure 13 Design Stator-Inlet-Flow-Angles Versus Span in Relation to Measured Low-Loss Incidence Angles

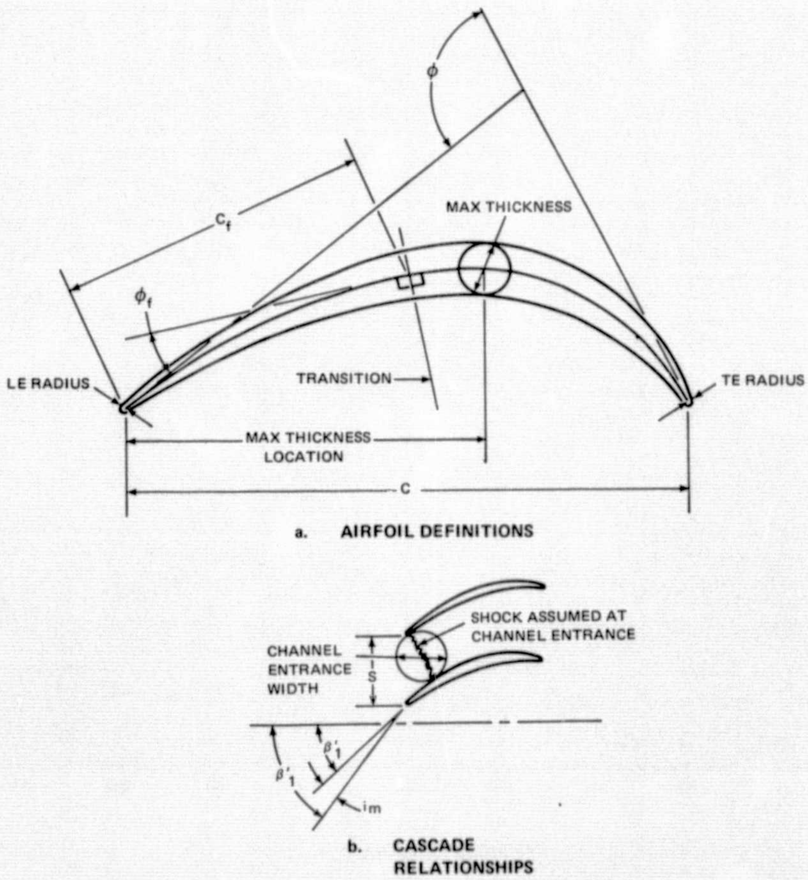


Figure 14 MCA Airfoil Definitions and Cascade Relationships

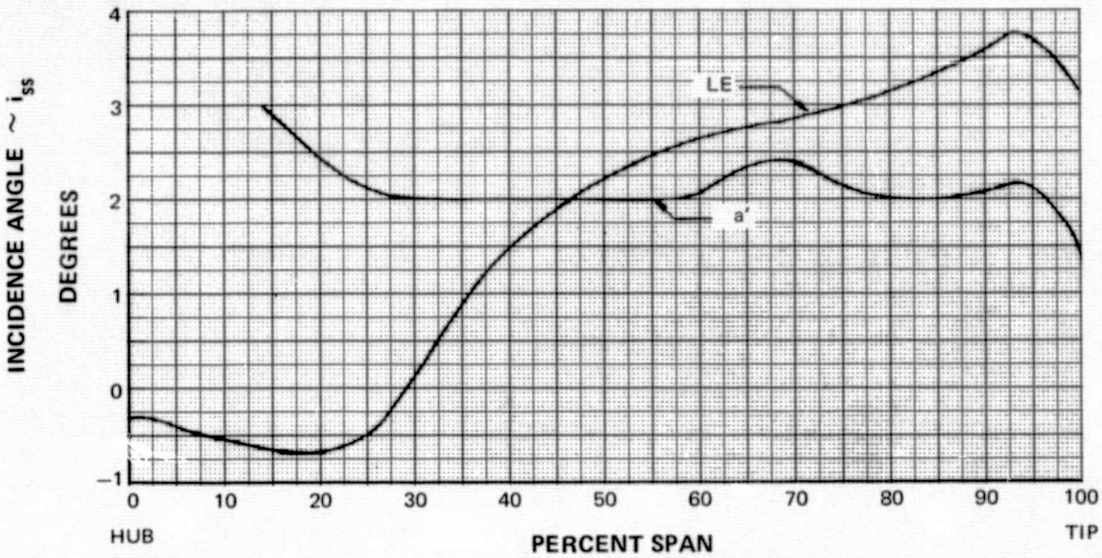


Figure 15 Rotor Incidence Angle to the Suction Surface Versus Span for the Redesigned Rotor

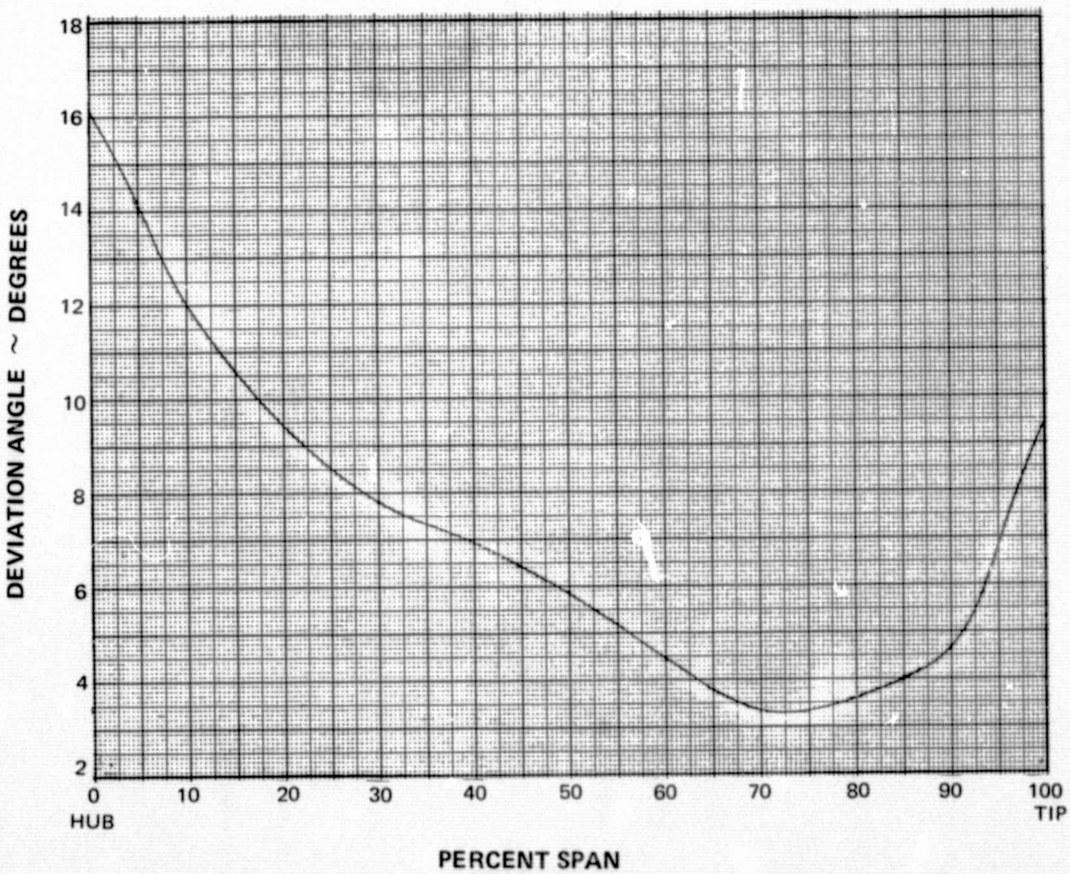


Figure 16 Rotor Deviation Angle Versus Span

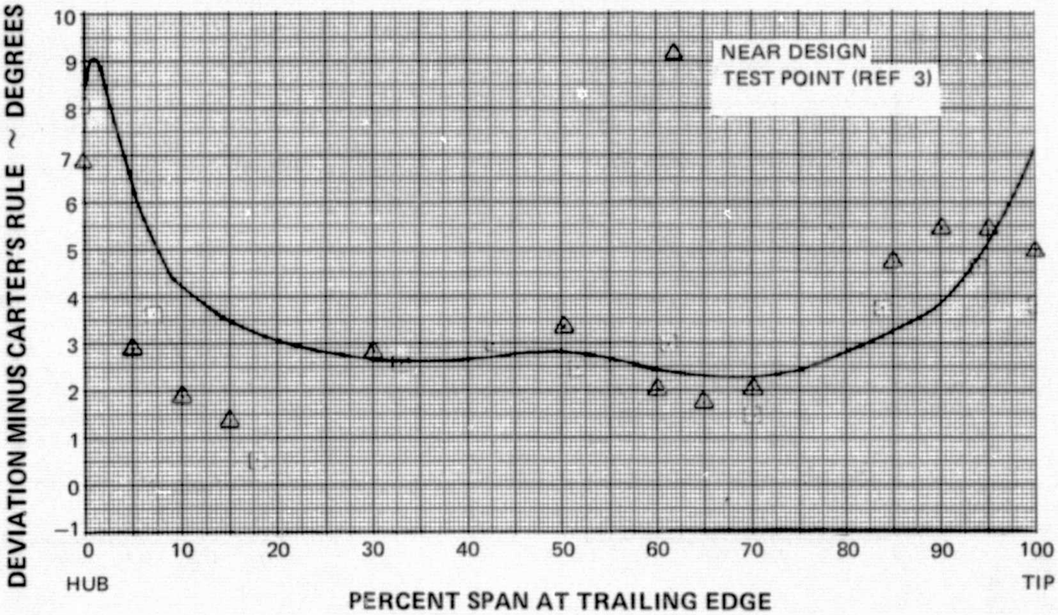


Figure 17 Spanwise Distribution of Difference Between Rotor Design Deviation Angles and Deviation Angles Predicted by Carter's Rule

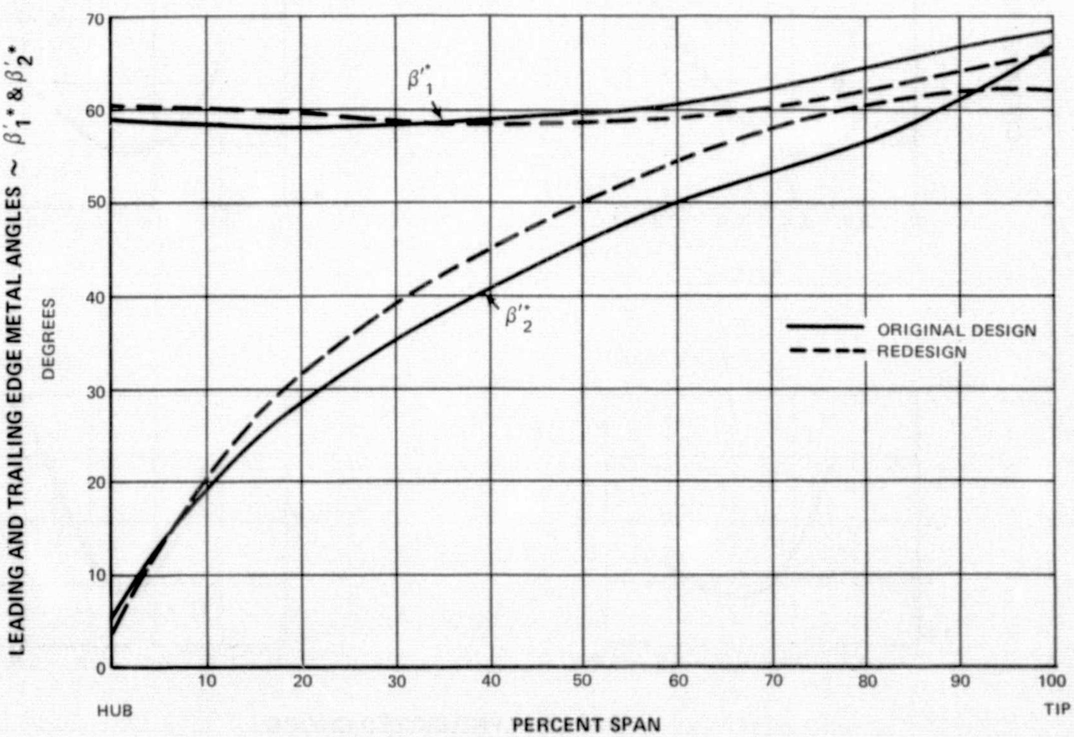


Figure 18 Rotor Leading and Trailing Edge Metal Angle Versus Span for the Redesigned and Original Rotor

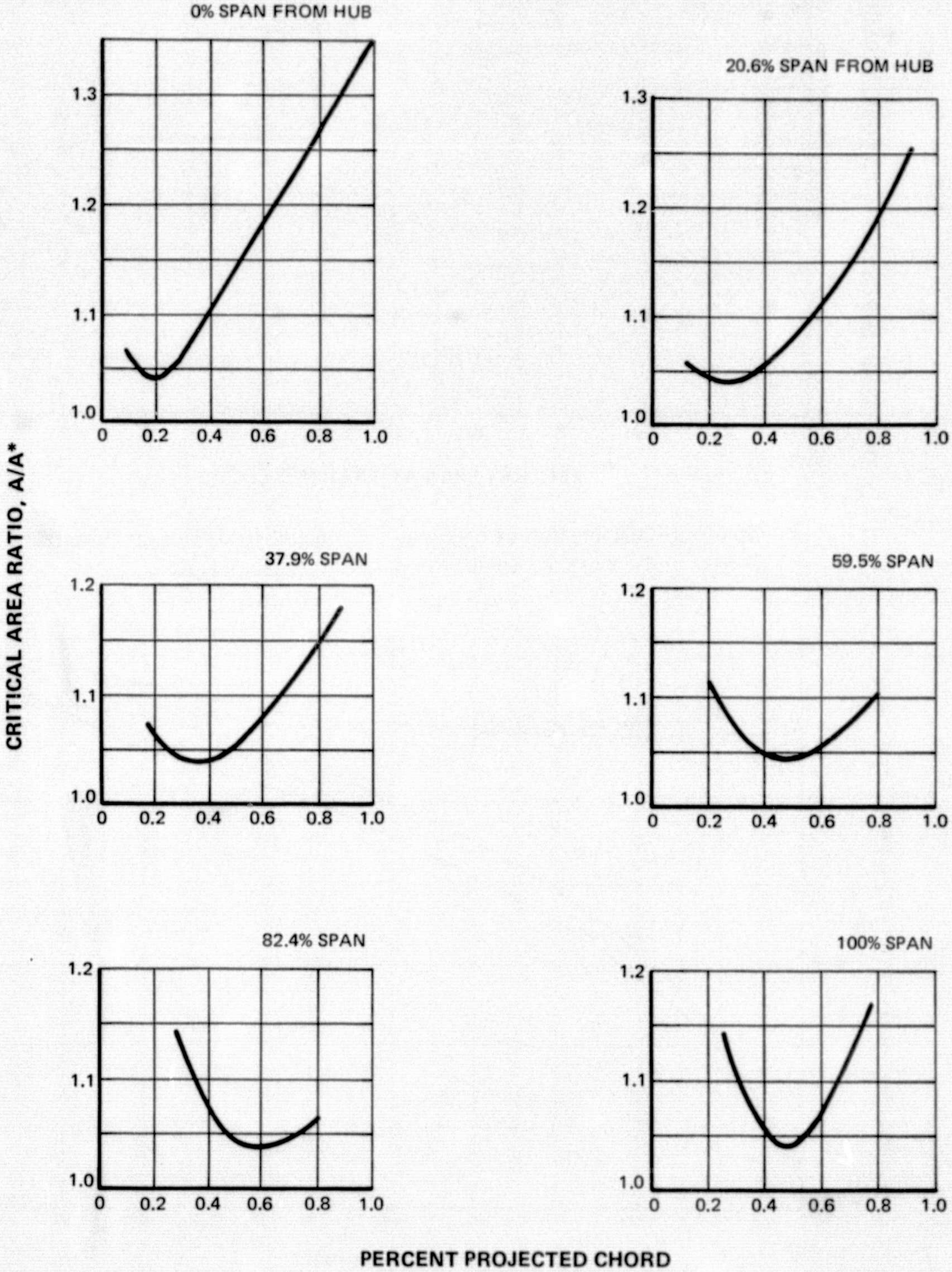


Figure 19 Channel Area Ratios Versus Axial Distance

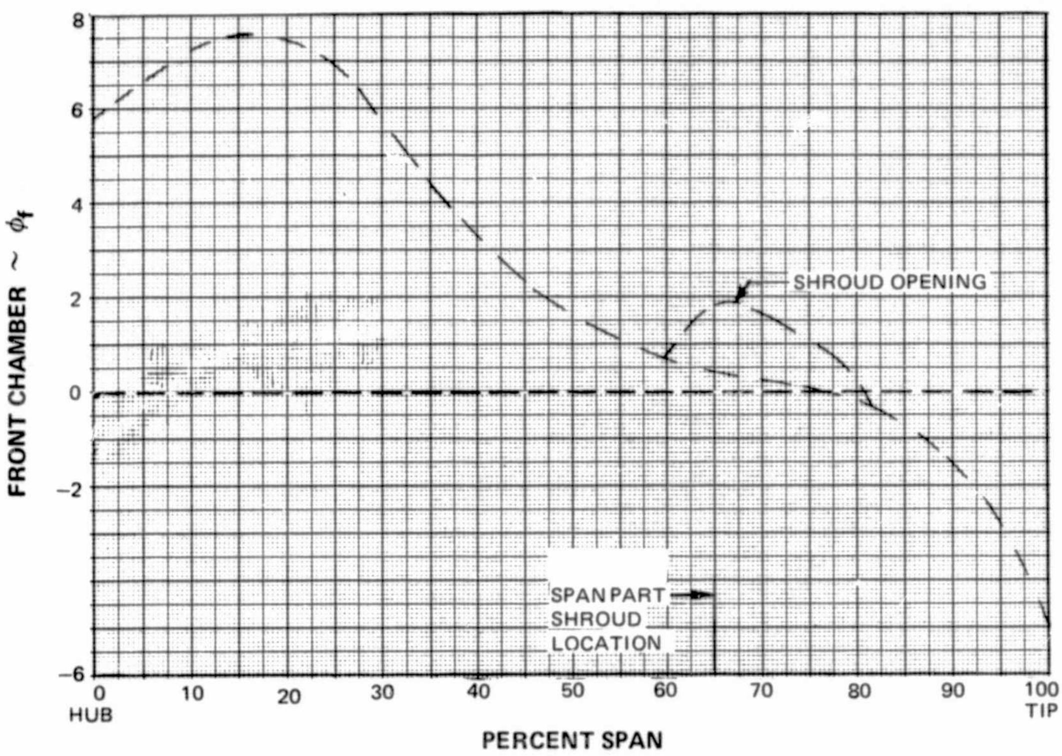


Figure 20 Front Section Camber Angle Versus Span

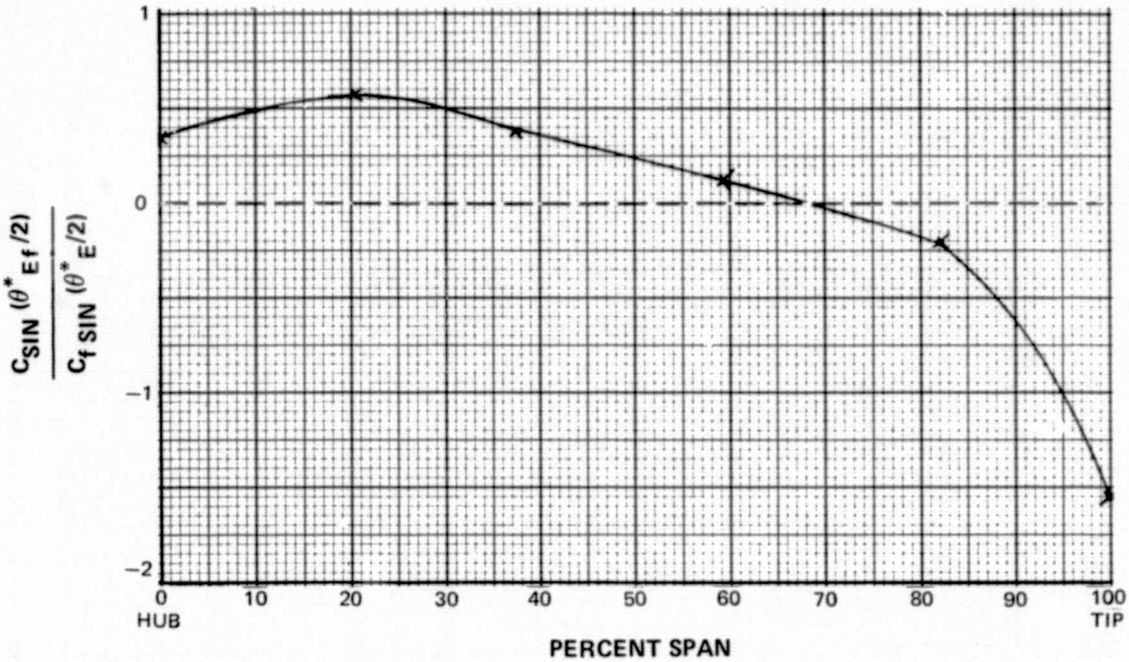


Figure 21 Airfoil Camber Distribution Parameter

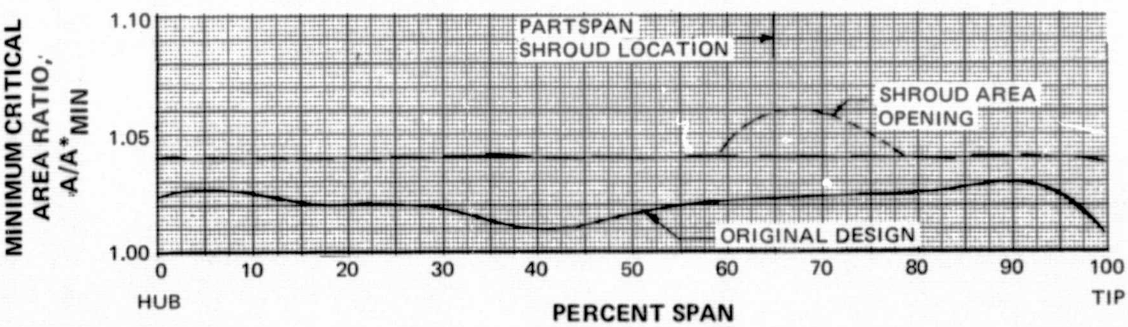


Figure 22 Minimum Critical Area Ratio (A/A*) Versus Span for the Redesigned and Original Rotor

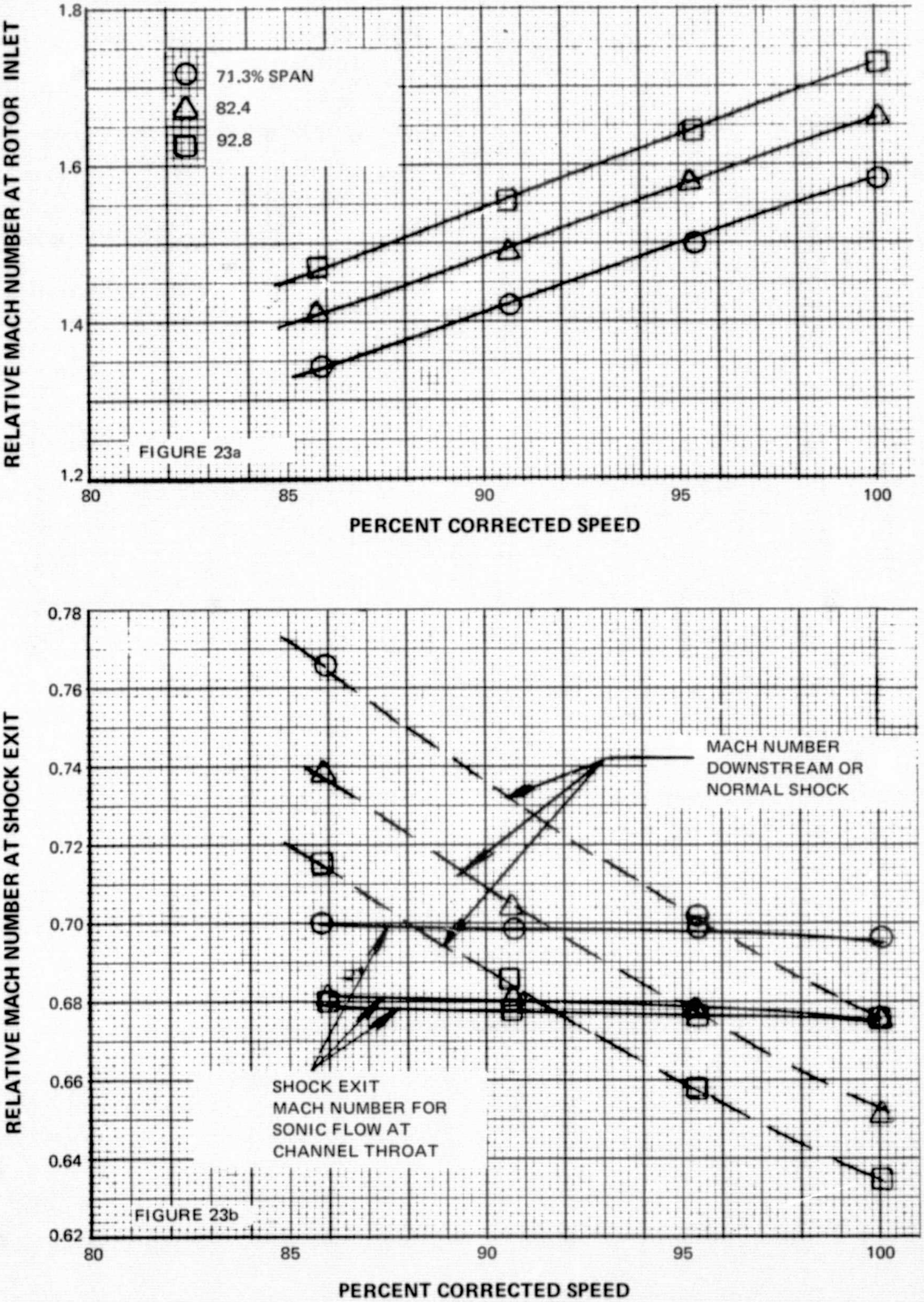


Figure 23 Mach Number and Speeds for Started-Shock System at Three Spanwise Locations

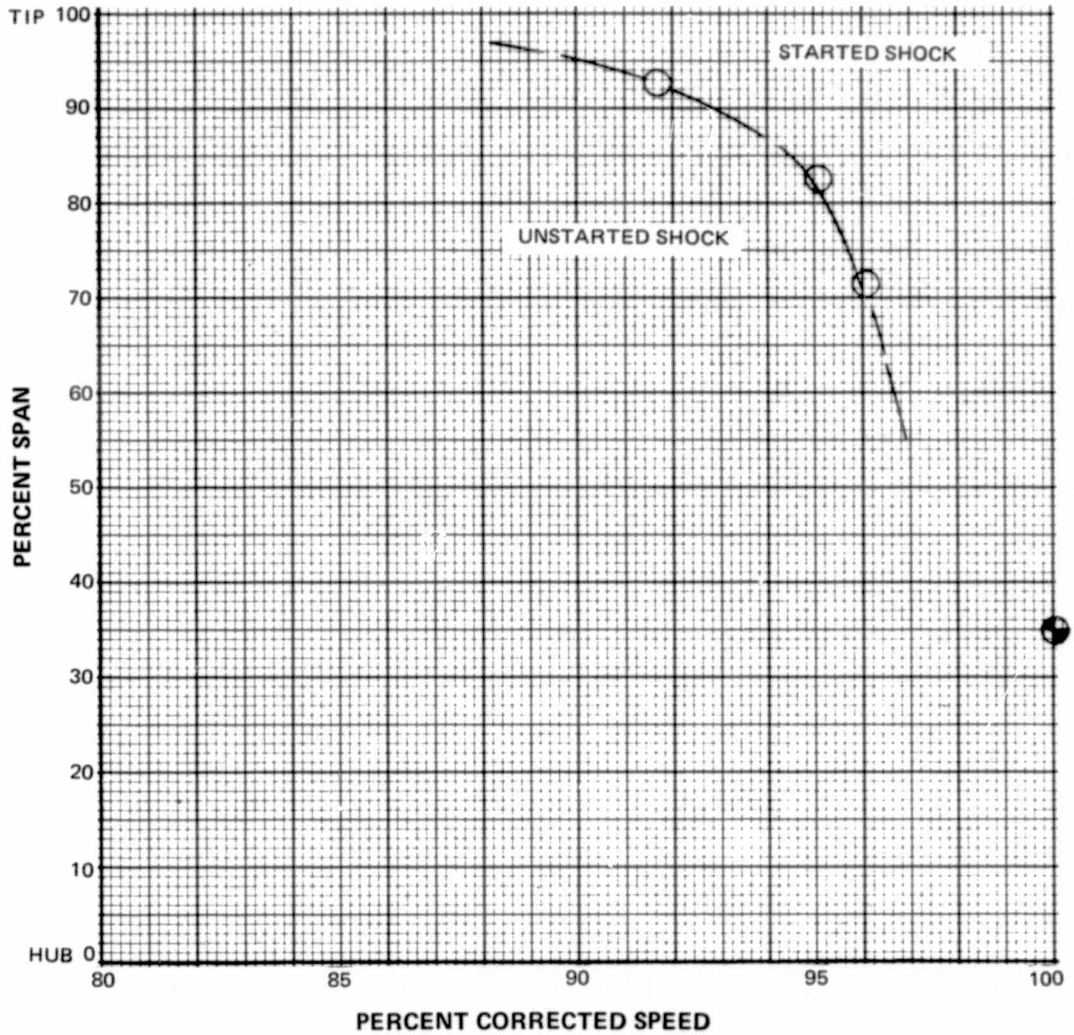


Figure 24 Percent Span Having Started-Shock System Versus Speed

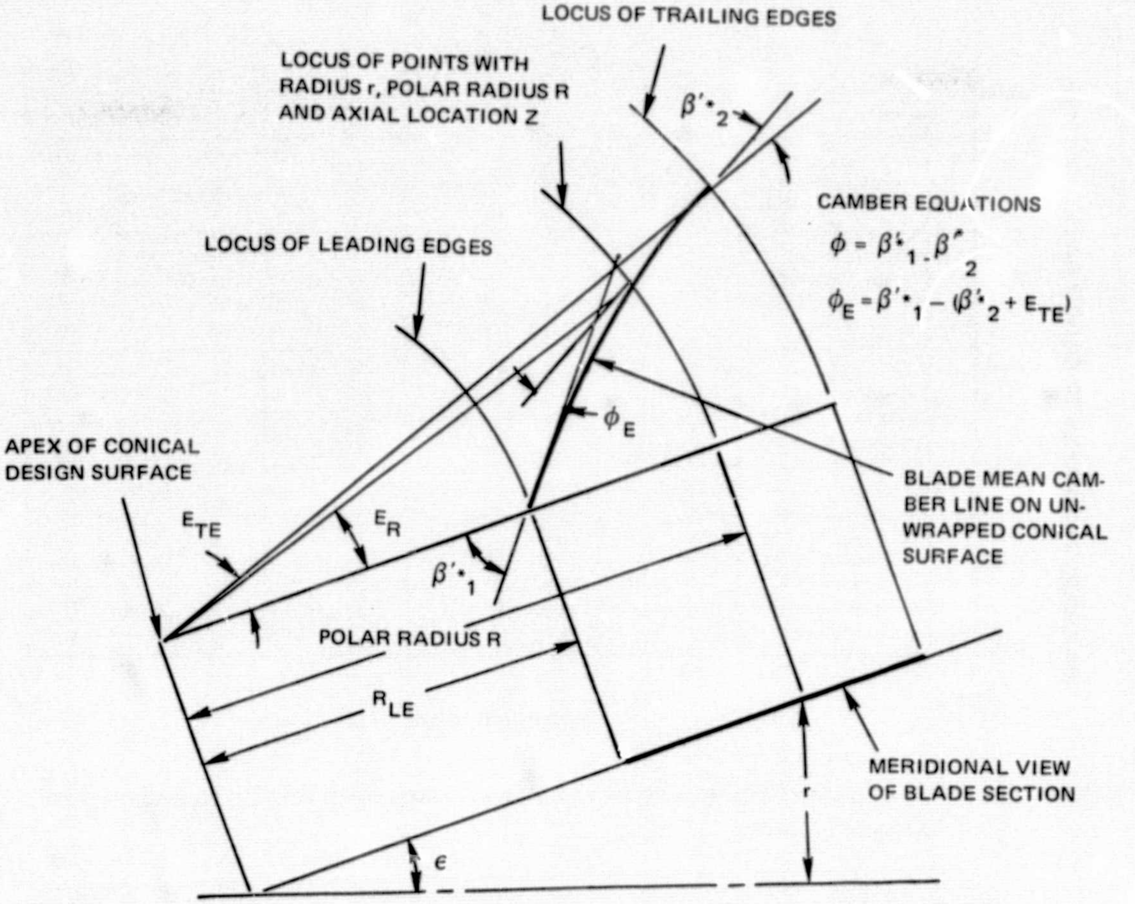


Figure 25 Meridional View and Polar Representation of MCA Airfoil Mean Camber Line

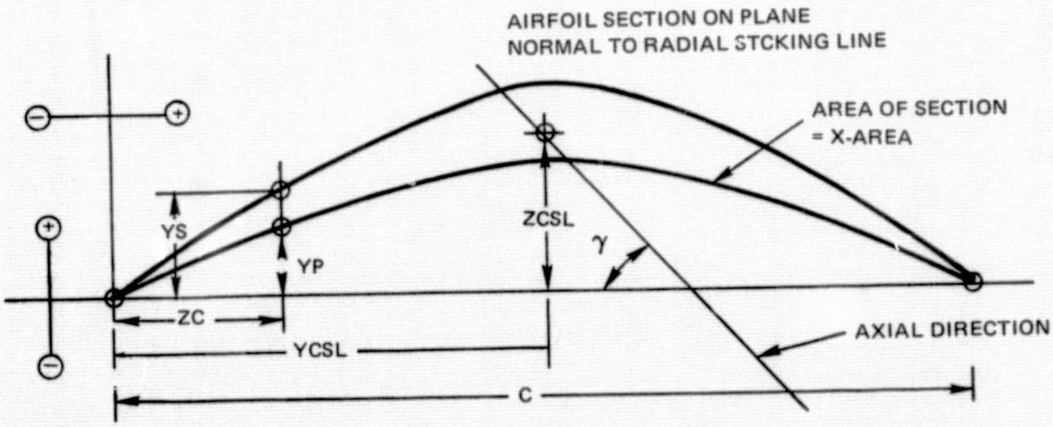


Figure 26 Airfoil Coordinate Definition for Manufacturing Sections

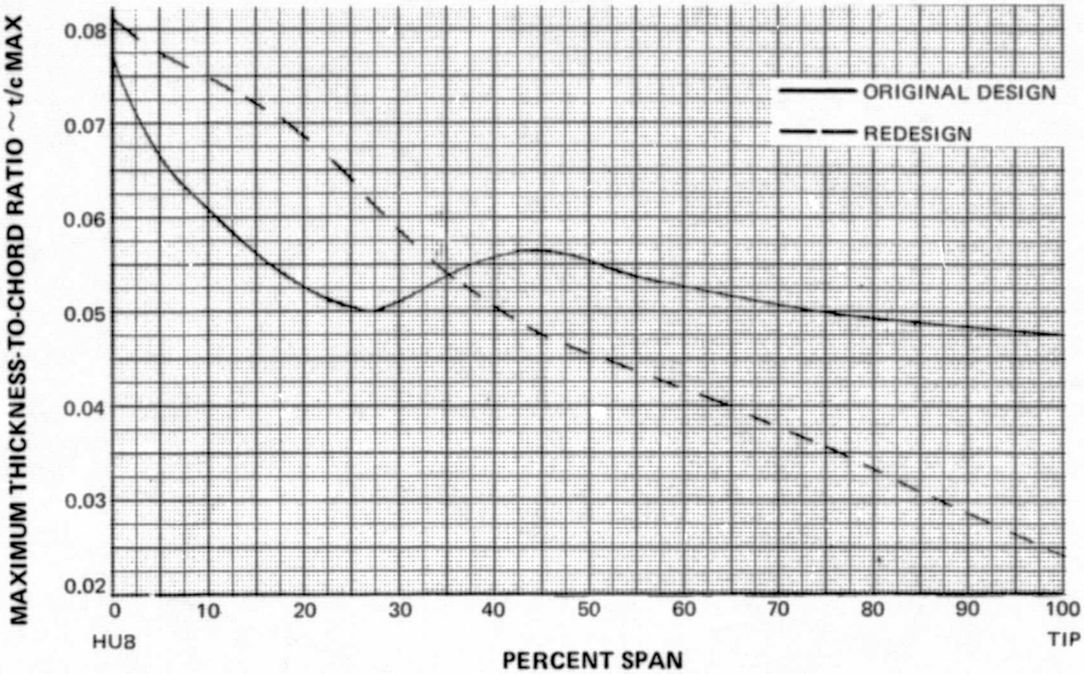


Figure 27 Maximum-Thickness to Chord Ratio Versus Span for the Redesigned and Original Rotor

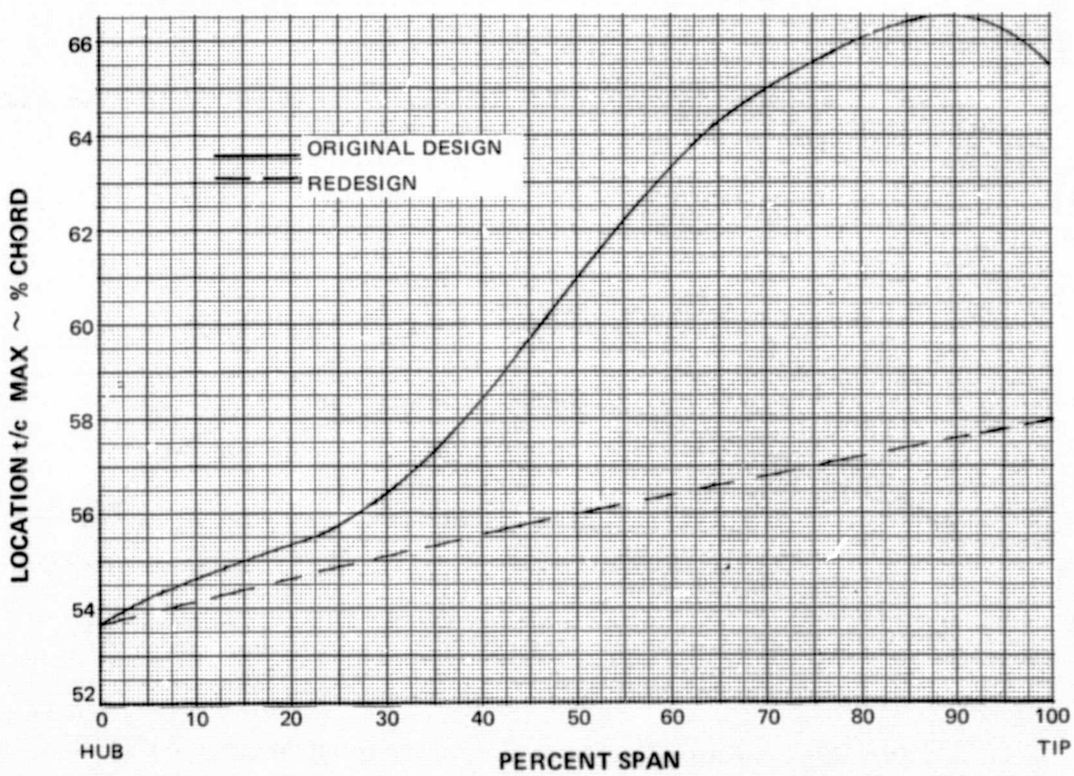


Figure 28 Chordwise Location of Airflow Maximum-Thickness Versus Span for the Redesigned and Original Rotor

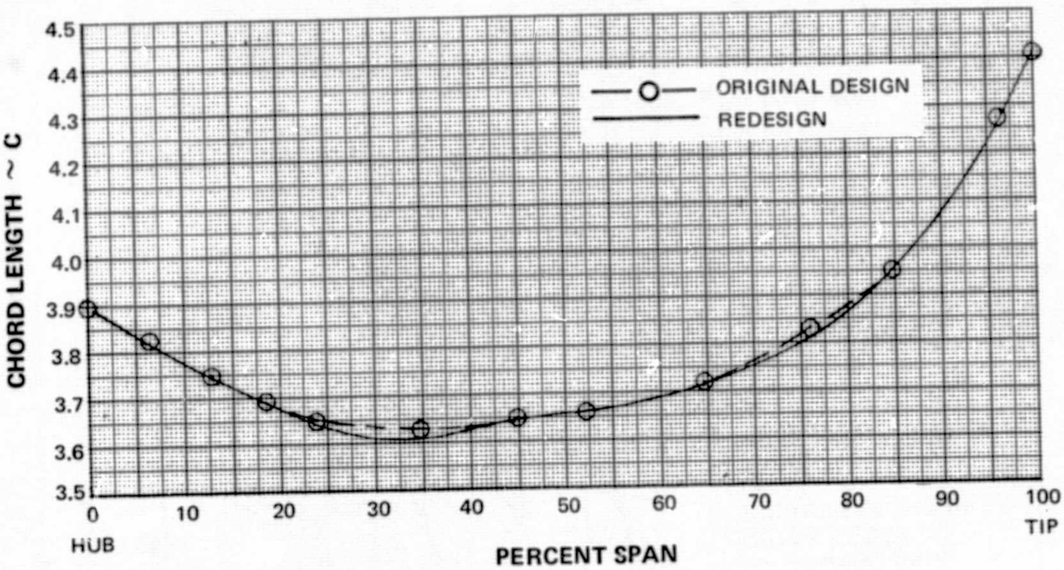


Figure 29 Rotor Chord Length on Conical Surfaces Versus Span for the Redesigned and Original Rotor

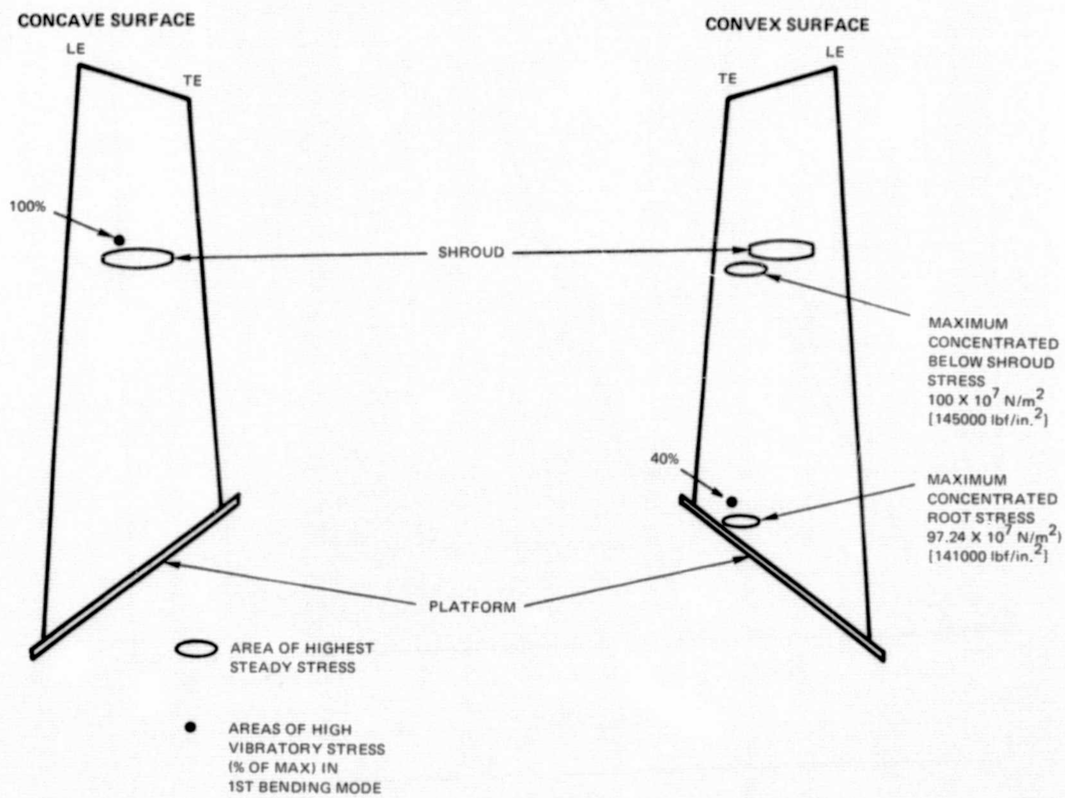


Figure 30 Rotor Blade Maximum Stress Locations

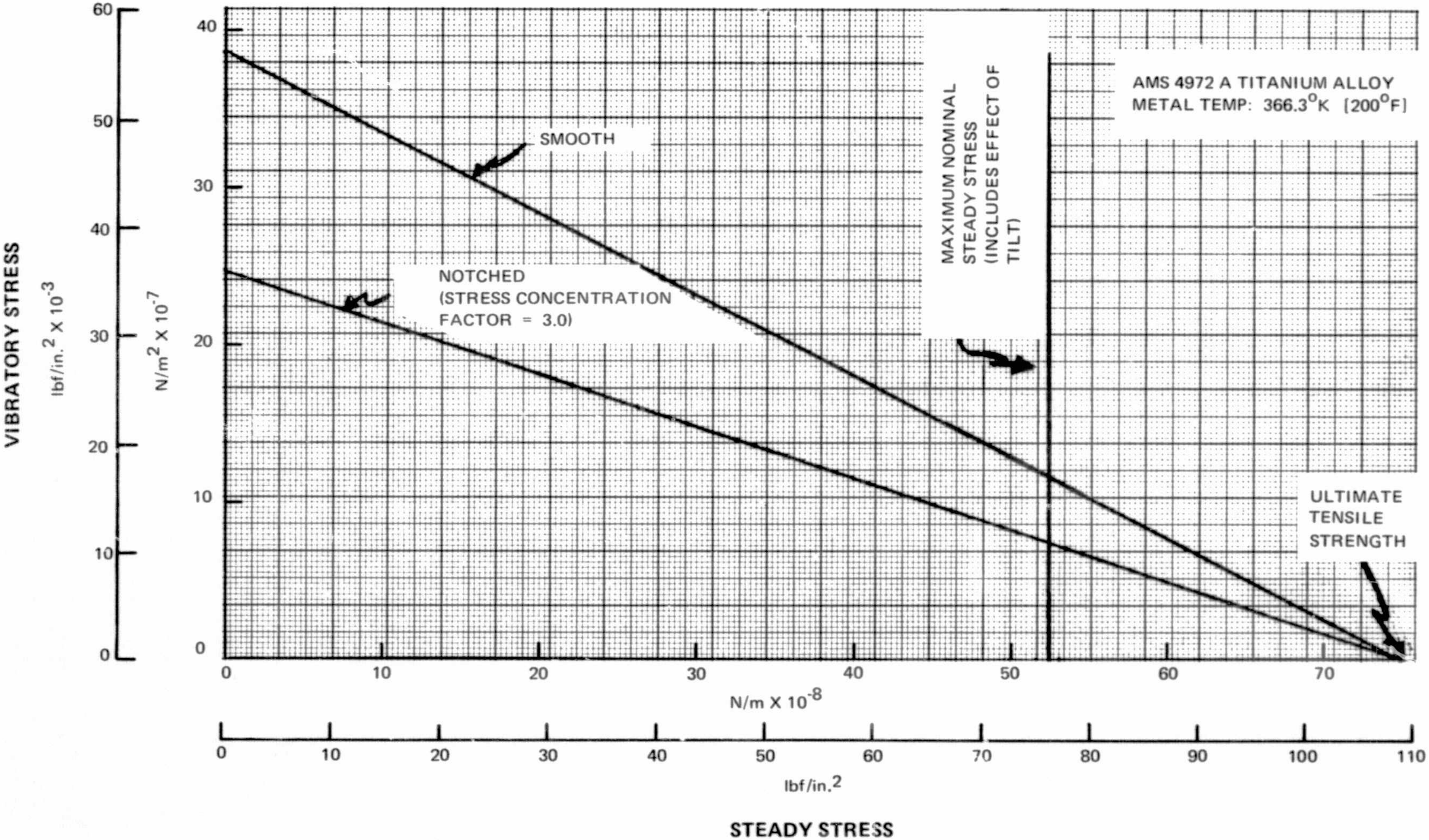


Figure 31 Modified Goodman Diagram

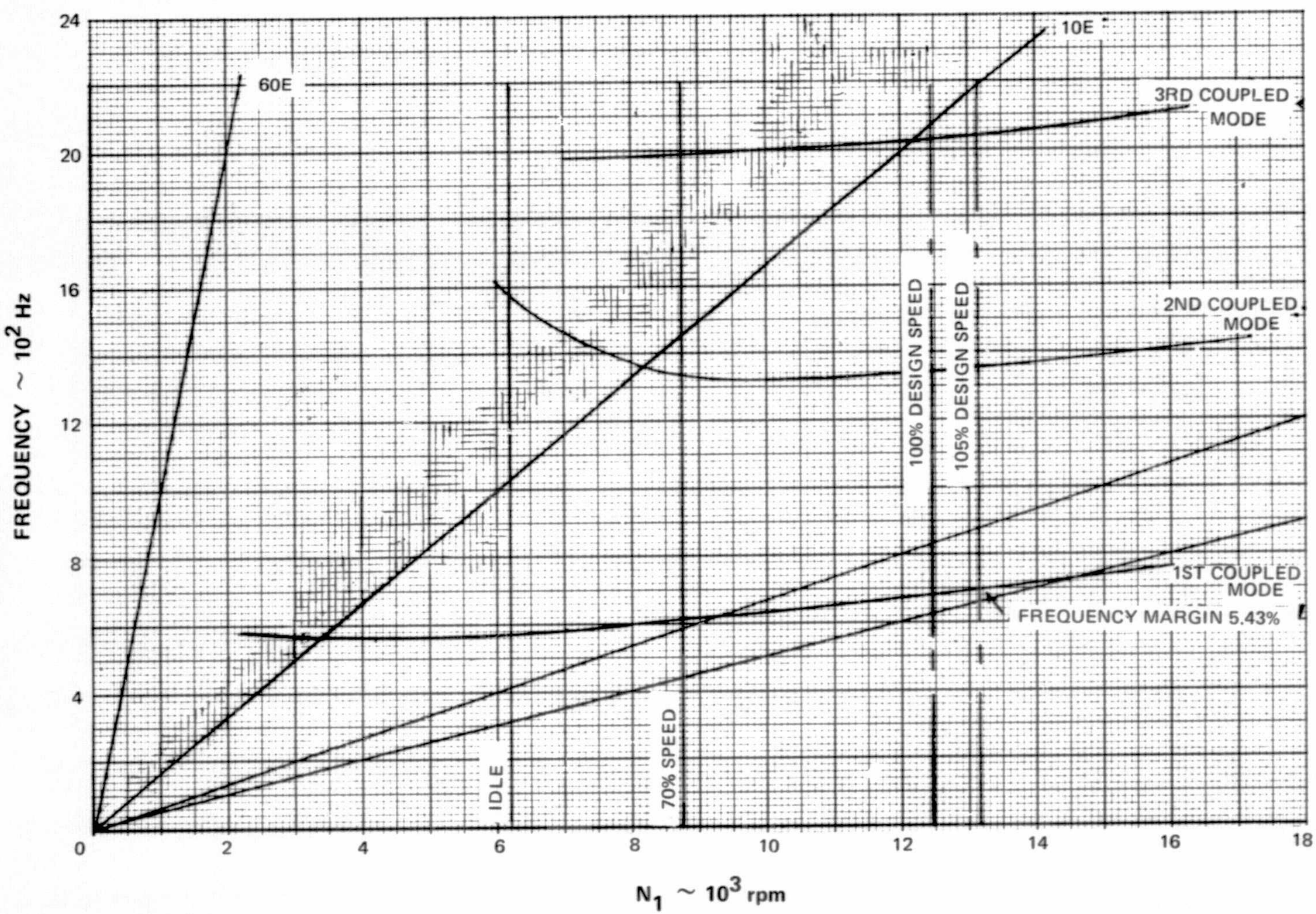


Figure 32 Blade-Disk-Shroud Coupled Mode Resonance Diagram

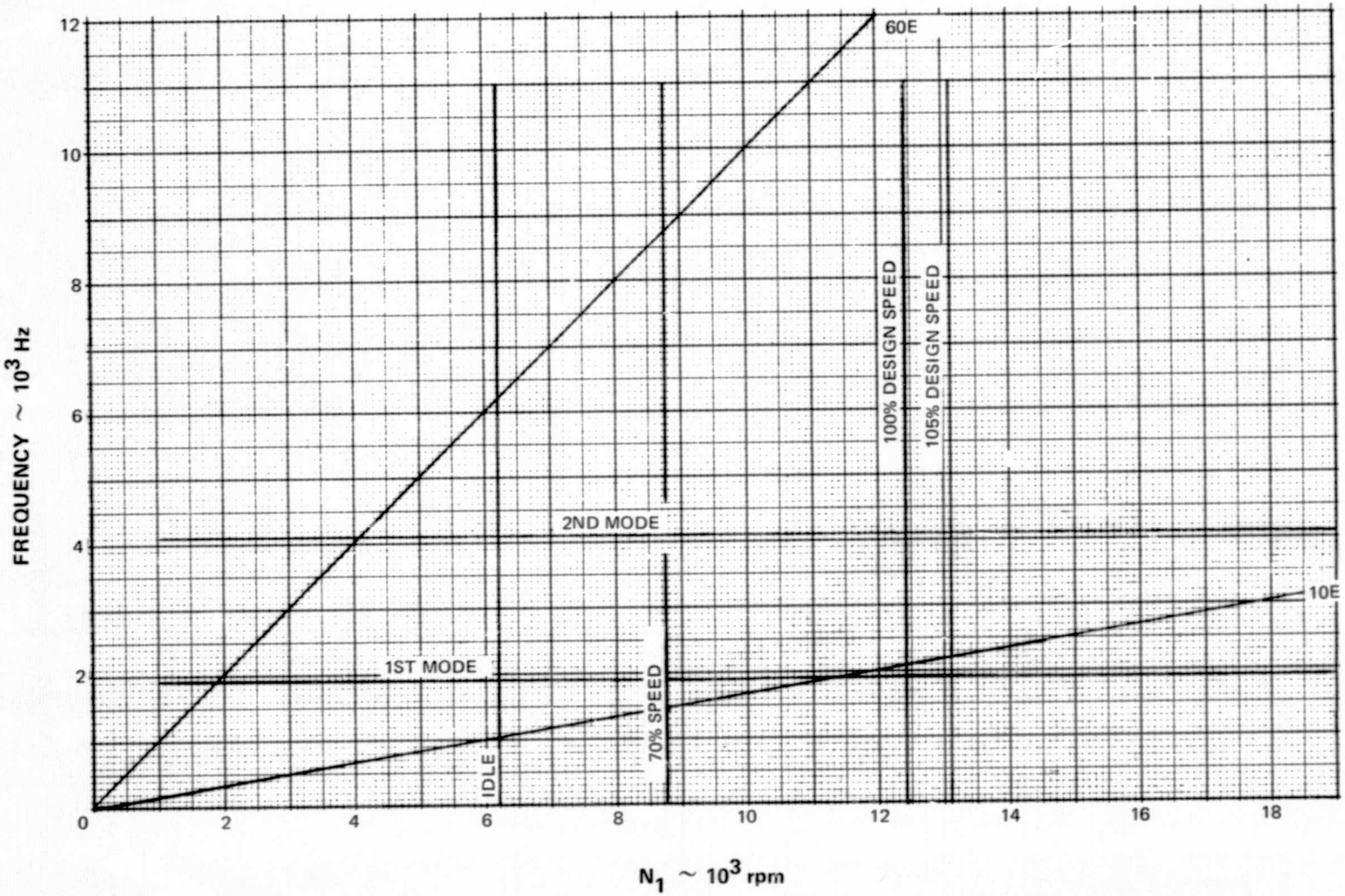
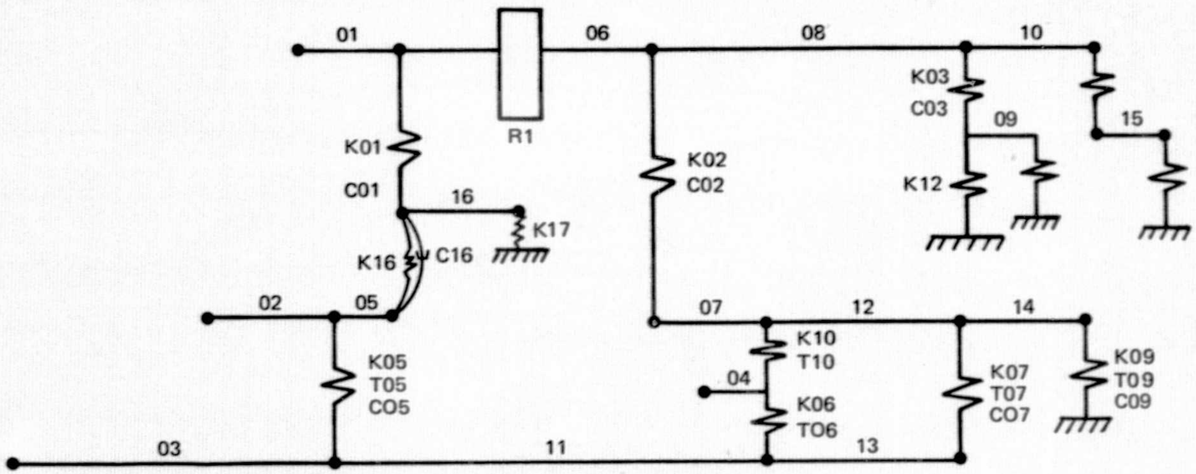


Figure 33 Blade-Tip Chordwise Bending Mode Resonance Diagram



LINEAR SPRINGS

	(n/m X 10-8)	(lbf/in. X 10^{-6})
K01 =	5.4	3
K02 =	3.6	2
K03 =	2.7	1.5
K04 =	3.6	2
K05 =	3.6	2
K06 =	36	20
K07 =	18	10
K08 =	18	10
K09 =	18	10
K10 =	180	100
K11 =	18	10
K12 =	1800	1000
K17 =	3.6	2

TORSIONAL SPRINGS

	(m-N/rad X 10^{-9})	(in.-lbf/deg X 10^{-8})
T05 =	.98	1.5
T06 =	1.3	2
T07 =	6.5	10
T08 =	.65	1
T09 =	.65	1
T10 =	6.5	10
T11 =	.65	1

DAMPER SPRINGS

	(N/m-sec)	(lbf/in.-sec)
C01 =	1750	10
C02 =	1750	10
C03 =	1750	10
C04 =	1750	10
C05 =	17500	100
C07 =	17500	100
C08 =	35000	200
C09 =	35000	200
C11 =	35000	200

Figure 34 Rotor-Frame Critical-Speed Spring-Mass System

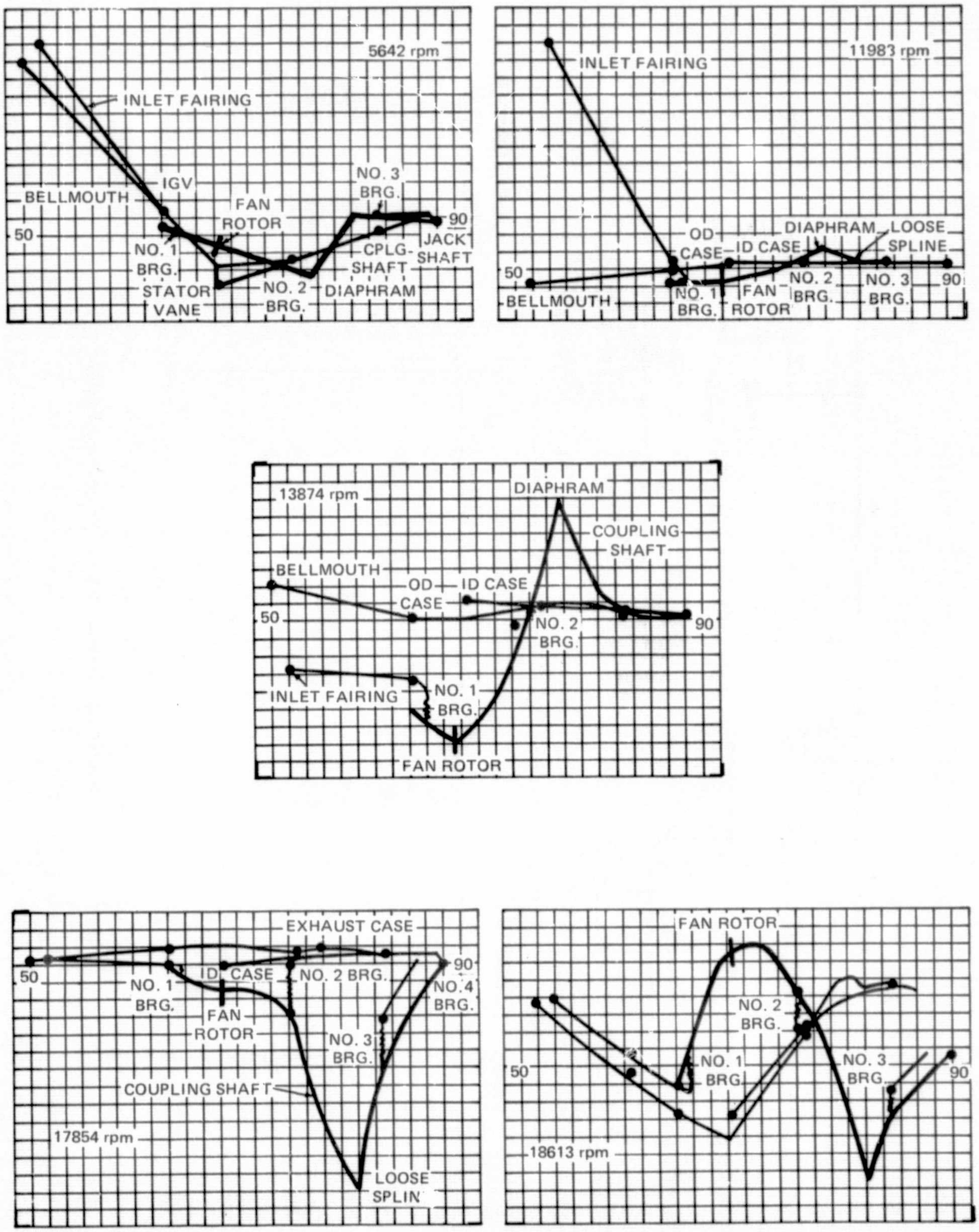


Figure 35 Critical-Speed Mode Shapes

APPENDIX A

NOMENCLATURE

Symbol	Definition
A	area
A/A^*	(area)/(sonic flow area)
a	distance along chord line to maximum camber point from leading edge
b	rotor semichord at 75 percent of span from root
c	aerodynamic chord, i.e., along the flow surface
D	diffusion factor for rotor $= 1 - \dfrac{V'_2}{V'_1} + \dfrac{r_2 V_{\theta 2} - r_1 V_{\theta 1}}{(r_1 + r_2)\,\sigma V'_1}$ for stator $= 1 - \dfrac{V_4}{V_3} + \dfrac{r_3 V_{\theta 3} - r_4 V_{\theta 4}}{(r_3 + r_4)\,\sigma V_3}$
DCA	double-circular-arc
E	angle on conical surface of revolution (see Figure 25)
E	excitations per rotor revolution
i_m	incidence angle between inlet air direction and line tangent to blade mean camber line at leading edge, degrees
i_{ss}	incidence angle between inlet air direction and line tangent to blade suction surface at leading edge, degrees
$\bar{K}$	blockage factor, actual/effective flow area
$K_{1\text{-}8}$	radial spring rates
K_t	stress concentration factor
LE	leading edge
M	Mach number
MCA	multiple-circular-arc

NOMENCLATURE (Continued)

Symbol	Definition
N	rotor speed, rpm
p	pressure
P/A	centrifugal pull stress
PC	precompression blade
r	radius
R	distance along conical surface from apex to blade (see Figure 25)
R_c	streamline radius of curvature
s	blade spacing
T	temperature
t	blade maximum thickness
TE	trailing edge
$T_{1\text{-}4}$	torsional spring rates
U	rotor tangential speed
V	air velocity
W	weight flow
x conical	distance in unwrapped conical plane
Y_p	airfoil coordinate of pressure surface normal to chord line
Y_s	airfoil coordinate of suction surface normal to chord line
Y_{ccg}	vertical distrance to airfoil center of gravity from chord line
y	length along calculation station
y conical	distance normal to x conical

NOMENCLATURE (Continued)

Symbol	Definition
Z	axial distance
Z^* ratio	shroud modulus/airfoil modulus
Z_c	airfoil coordinate parallel to chord line
Z_{ccg}	horizontal distance to airfoil center of gravity from leading edge along chord line
β	absolute air angle $= \mathrm{COT}^{-1} \ (Vm/V_\theta)$
β'	relative air angle $= \mathrm{COT}^{-1} \ (Vm/V'\theta)$
β^*	metal angle, angle between tangent to mean camber line and meridional direction
γ	blade chord angle, angle between chord and axial direction
$\delta°$	deviation angle - exit air angle minus metal angle at trailing edge
ϵ	angle between tangent to streamline projected on meridional plane and axial direction
$\bar{\epsilon}$	cone angle $= \mathrm{TAN}^{-1} \ \dfrac{(r_{te} - r_{le})}{(Z_{te} - Z_{le})}$
η_{ad}	adiabatic efficiency
θ	circumferential direction
λ	angle of calculation station measured from axial direction
ρ	density
σ	solidity or stress
ϕ	camber angle, difference between blade angles at leading and trailing edges on conical surface (see Figure 25)
ϕ_E	camber angle, difference between blade angles at leading and trailing edges on the unwrapped conical surface (see Figure 25)

NOMENCLATURE (Continued)

Symbol	Definition
ϕ_{Ef}	front camber angle, difference between blade angles at leading edge and MCA transition point on the unwrapped conical surface
ω	angular velocity
ω_t	torsional frequency
$\overline{\omega}$	total pressure loss coefficient, mass average defect in relative total pressure divided by difference between inlet stagnation and static pressures

Subscripts

av	average
f	front
le	leading edge
m	meridional direction (r - z plane)
p	profile
r	radial direction
ss	suction surface
t	total or stagnation
te	trailing edge
z	axial direction
θ	circumferential
1	station into rotor along leading edge
2	station out of rotor along trailing edge
3	station into stator along leading edge
4	station out of stator along trailing edge

NOMENCLATURE (Continued)

superscripts

$'$	relative to rotor
$*$	designates blade metal angle
$^{\circ}$	degrees of arc or temperature

APPENDIX B

AERODYNAMIC SUMMARY FOR REDESIGNED ROTOR

RADIAL LOCATIONS OF ROTOR DESIGN BLADE ELEMENT DATA

STREAMLINE	FLOW FROM HUB (%)	SPAN AT ROTOR INLET (%)	SPAN AT ROTOR EXIT (%)
1	0	0	0
2	4.2	8.1	5
3	7.9	15.1	10
4	11.7	21.1	15
5	25.5	37.6	30
6	45.9	57.8	50
7	56.9	67.2	60
8	62.3	71.7	65
9	67.9	75.8	70
10	85.0	88.9	85
11	90.1	92.7	90
12	95.2	96.7	95
13	100	100	100

NOMENCLATURE USED IN APPENDIX B PRINTOUTS

ESPI	ϵ
INCS	i_{ss}
INCM	i_m
DEV	δ°
TURN	$\beta'_1 - \beta'_2$
RHOVM	ρV_m
D-FAC	D
OMEGA-B	$\bar{\omega}$
LOSS-P	$\bar{\omega} \cos \beta'_2 / 2\delta$
EFF-P	η_p
EFF-A	η_a

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AERODYNAMIC SUMMARY FOR REDESIGNED ROTOR

U.S. CUSTOMARY UNIT

RUN NO 0, SPEED CODE 0, POINT NO 0

SL	EPSI-1	EPSI-2	V-1	V-2	VM-1	VM-2	Vθ-1	Vθ-2	B-1	B-2	M-1	M-2	U-1	U-2	M'-1	M'-I	V'-1	V'-2
	DEGREE	DEGREE	FT/SEC	FT/SEC	FT/SEC	FT/SEC	FT/SEC	FT/SEC	DEGREE	DEGREE			FT/SEC	FT/SEC			FT/SEC	FT/SEC
1	33.777	35.858	428.1	1062.1	428.1	577.5	0.0	891.3	0.0	56.8	0.3893	0.8959	897.3	1094.8	0.9040	0.5165	994.2	612.3
2	29.078	31.239	474.4	1027.0	474.4	575.2	0.0	850.8	0.0	56.0	0.4329	0.8638	970.8	1127.4	0.9859	0.5368	1080.5	638.2
3	24.910	27.206	514.1	994.1	514.1	571.4	0.0	813.4	0.0	55.1	0.4706	0.8341	1033.3	1159.5	1.0565	0.5605	1154.1	668.0
4	21.235	23.225	547.7	967.1	547.7	567.2	0.0	782.3	0.0	54.2	0.5029	0.8095	1087.7	1192.1	1.1182	0.5853	1217.8	699.2
5	11.148	12.786	629.8	907.5	629.8	554.1	0.0	718.6	0.0	52.4	0.5830	0.7545	1240.0	1289.5	1.2875	0.6615	1390.7	795.6
6	-0.196	2.273	689.2	855.8	689.2	536.0	0.0	667.1	0.0	51.2	0.6424	0.7052	1419.4	1418.9	1.4707	0.7608	1577.9	923.3
7	-5.122	-2.362	699.0	835.1	699.0	525.7	0.0	648.9	0.0	50.9	0.6523	0.6851	1503.7	1483.6	1.5474	0.8093	1658.3	986.5
8	-7.429	-4.584	699.0	825.6	699.0	521.5	0.0	640.1	0.0	50.6	0.6522	0.6759	1544.5	1516.2	1.5820	0.8347	1695.3	1019.6
9	-9.508	-6.798	696.1	816.7	696.1	516.8	0.0	632.3	0.0	50.5	0.6494	0.6672	1582.0	1548.3	1.6123	0.8592	1728.4	1051.7
10	-15.499	-13.559	671.9	791.3	671.9	489.0	0.0	622.2	0.0	51.4	0.6249	0.6410	1699.5	1645.7	1.6998	0.9188	1827.5	1134.3
11	-17.070	-15.838	662.0	782.7	662.0	475.6	0.0	621.6	0.0	52.3	0.6150	0.6318	1734.3	1678.3	1.7247	0.9355	1856.4	1158.8
12	-18.262	-17.794	651.7	777.2	651.7	427.5	0.0	649.1	0.0	56.3	0.6048	0.6218	1770.2	1710.4	1.7505	0.9154	1886.4	1144.2
13	-18.623	-19.442	646.3	768.3	646.3	387.8	0.0	663.3	0.0	59.7	0.5994	0.6106	1800.1	1743.0	1.7739	0.9118	1912.6	1147.2

SL	INCS	INCM	DEV	TURN	RHOVM-1	RHOVM-2	D-FAC	OMEGA-B	LOSS-P	PO2/	%EFF-P	%EFF-A	B'-1	B'-2	Vθ'-1	Vθ'-2	PO/PO
	DEGREE	DEGREE	DEGREE	DEGREE				TOTAL	TOTAL	PO1	TOT	TOT	DEGREE	DEGREE	FT/SEC	FT/SEC	INLET
1	-1.44	3.46	16.22	44.48	30.38	57.08	0.5775	0.1412	0.0259	2.4572	94.74	94.03	63.73	19.25	-897.3	-203.4	2.4572
2	-1.50	3.34	14.18	37.78	33.09	57.60	0.5861	0.1250	0.0236	2.4203	94.55	93.83	63.50	25.72	-970.8	-276.6	2.4203
3	-1.57	3.21	11.70	31.88	35.27	57.94	0.5865	0.1116	0.0212	2.3871	94.46	93.75	63.26	31.38	-1033.3	-346.0	2.3871
4	-1.47	3.22	10.69	27.15	37.02	58.14	0.5846	0.1036	0.0197	2.3653	94.30	93.57	63.02	35.87	-1087.7	-408.8	2.3653
5	0.35	4.29	7.80	17.07	40.86	58.37	0.5674	0.0949	0.0174	2.3349	93.51	92.70	63.00	45.93	-1240.0	-570.8	2.3349
6	1.58	4.97	5.82	9.57	43.22	57.87	0.5385	0.1057	0.0180	2.3283	91.47	90.40	64.10	54.53	-1419.4	-751.8	2.3283
7	1.93	5.10	4.45	7.36	43.58	57.24	0.5228	0.1165	0.0190	2.3272	90.07	88.83	65.05	57.69	-1503.7	-834.8	2.3272
8	2.02	5.08	3.80	6.55	43.58	57.00	0.5134	0.1212	0.0193	2.3271	89.43	88.11	65.61	59.06	-1544.5	-876.2	2.3271
9	2.20	5.12	3.25	5.85	43.48	56.67	0.5041	0.1265	0.0196	2.3271	88.74	87.34	66.22	60.37	-1582.0	-916.0	2.3271
10	2.89	5.17	4.04	4.18	42.57	53.89	0.4847	0.1579	0.0218	2.3271	85.35	83.53	68.29	64.11	-1699.5	-1023.5	2.3271
11	3.17	5.29	4.69	3.49	42.18	52.46	0.4795	0.1715	0.0224	2.3271	83.96	81.97	69.01	65.52	-1734.3	-1056.7	2.3271
12	2.99	4.87	7.01	1.79	41.77	46.69	0.4980	0.2216	0.0259	2.3271	79.57	77.04	69.63	67.84	-1770.2	-1061.3	2.3271
13	2.85	4.55	9.44	-0.09	41.55	42.17	0.5044	0.2536	0.0262	2.3271	76.82	73.96	70.18	70.26	-1800.1	-1079.7	2.3271

TO/TO INLET	PO/PO INLET	EFF-AD INLET %	EFF-P INLET %	WC1/A1 LBM/SEC SOFT
1.3097	2.3400	88.38	89.67	38.70

TO2/TO1	PO2/PO1	EFF-AD ROTOR %	EFF-P ROTOR %
1.3097	2.3400	88.38	89.67

S.I. UNITS

RUN NO 0, SPEED CODE 0, POINT NO 0

SL	EPSI-1	EPSI-2	V-1	V-2	VM-1	VM-2	Vθ-1	Vθ-2	B-1	B-2	M-1	M-2	U-1	U-2	M'-1	M'-I	V'-1	V'-2
	RADIAN	RADIAN	M/SEC	M/SEC	M/SEC	M/SEC	M/SEC	M/SEC	RADIAN	RADIAN			M/SEC	M/SEC			M/SEC	M/SEC
1	0.5895	0.6258	130.5	323.7	130.5	176.0	0.0	271.7	0.0	0.9918	0.3893	0.8959	273.5	333.7	0.9040	0.5165	303.0	186.6
2	0.5075	0.5452	144.6	313.0	144.6	175.3	0.0	259.3	0.0	0.9772	0.4329	0.8638	295.9	343.6	0.9859	0.5368	329.3	194.5
3	0.4348	0.4748	156.7	303.0	156.7	174.2	0.0	247.9	0.0	0.9617	0.4706	0.8341	314.9	353.4	1.0565	0.5605	351.8	203.6
4	0.3706	0.4053	166.9	294.7	166.9	172.9	0.0	238.7	0.0	0.9456	0.5029	0.8095	331.5	363.3	1.1182	0.5853	371.2	213.1
5	0.1946	0.2232	192.0	276.6	192.0	168.9	0.0	219.0	0.0	0.9153	0.5830	0.7545	377.9	393.0	1.2875	0.6615	423.9	242.5
6	-0.0034	0.0397	210.1	260.8	210.1	163.4	0.0	203.3	0.0	0.8943	0.6424	0.7052	432.6	432.5	1.4707	0.7608	480.9	281.4
7	-0.0894	-0.0412	213.1	254.5	213.1	160.2	0.0	197.6	0.0	0.8878	0.6523	0.6851	458.3	452.2	1.5474	0.8093	505.4	300.7
8	-0.1297	-0.0800	213.0	251.6	213.0	158.9	0.0	195.1	0.0	0.8837	0.6522	0.6759	470.7	462.1	1.5820	0.8347	516.7	310.8
9	-0.1659	-0.1185	212.2	248.9	212.2	157.5	0.0	192.7	0.0	0.8816	0.6494	0.6672	482.2	471.9	1.6123	0.8592	526.8	320.5
10	-0.2705	-0.2367	204.8	241.2	204.8	149.0	0.0	189.6	0.0	0.8970	0.6249	0.6410	518.0	501.6	1.6998	0.9188	557.0	345.7
11	-0.2979	-0.2764	201.8	238.5	201.8	145.0	0.0	189.5	0.0	0.9121	0.6150	0.6318	528.6	511.5	1.7247	0.9355	565.8	353.2
12	-0.3187	-0.3106	198.6	236.9	198.6	130.3	0.0	197.8	0.0	0.9833	0.6048	0.6218	539.5	521.3	1.7505	0.9154	574.9	348.7
13	-0.3250	-0.3393	197.0	234.2	197.0	116.2	0.0	202.2	0.0	1.0422	0.5994	0.6106	548.7	531.2	1.7739	0.9118	582.9	349.7

SL	INCS	INCM	DEV	TURN	RHOVM-1	RHOVM-2	D-FAC	OMEGA-B	LOSS-P	PO2/	%EFF-P	%EFF-A	B'-1	B'-2	Vθ'-1	Vθ'-2	PO/PO
	RADIAN	RADIAN	RADIAN	RADIAN				TOTAL	TOTAL	PO1	TOT	TOT	RADIAN	RADIAN	M/SEC	M/SEC	INLET
1	-0.0251	0.0604	0.2830	0.7764	30.38	57.08	0.5775	0.1412	0.0259	2.4572	94.74	94.03	1.1123	0.3359	-273.5	-62.0	2.4572
2	-0.0262	0.0583	0.2475	0.6593	33.09	57.60	0.5861	0.1250	0.0236	2.4203	94.55	93.83	1.1082	0.4489	-295.9	-84.3	2.4203
3	-0.0275	0.0561	0.2041	0.5565	35.27	57.94	0.5865	0.1116	0.0212	2.3871	94.46	93.75	1.1041	0.5476	-314.9	-105.5	2.3871
4	-0.0257	0.0562	0.[illegible]367	0.4738	37.02	58.14	0.5846	0.1036	0.0197	2.3653	94.30	93.57	1.0999	0.6261	-331.5	-124.6	2.3653
5	0.0061	0.0748	0.1361	0.2979	40.86	58.37	0.5674	0.0949	0.0174	2.3349	93.51	92.70	1.0996	0.8017	-377.9	-174.0	2.3349
6	0.0276	0.0867	0.1016	0.1670	43.22	57.87	0.5385	0.1057	0.0180	2.3283	91.47	90.40	1.1188	0.9518	-432.6	-229.1	2.3283
7	0.0336	0.0890	0.0777	0.1284	43.58	57.24	0.5228	0.1165	0.0190	2.3272	90.07	88.83	1.1353	1.0069	-458.3	-254.4	2.3272
8	0.0353	0.0886	0.0663	0.1143	43.58	57.00	0.5134	0.1212	0.0193	2.3271	89.43	88.11	1.1451	1.0308	-470.7	-267.0	2.3271
9	0.0384	0.0894	0.0567	0.1022	43.48	56.67	0.5041	0.1265	0.0196	2.3271	88.74	87.34	1.1558	1.0536	-482.2	-279.2	2.3271
10	0.0505	0.0902	0.0705	0.0730	42.57	53.89	0.4847	0.1579	0.0218	2.3271	65.35	83.53	1.1919	1.1189	-518.0	-311.9	2.3271
11	0.0554	0.0923	0.0818	0.0609	42.18	52.46	0.4795	0.1715	0.0224	2.3271	83.96	81.97	1.2045	1.1436	-528.6	-322.1	2.3271
12	0.0521	0.0851	0.1224	0.0313	41.77	46.69	0.4980	0.2216	0.0259	2.3271	79.57	77.04	1.2154	1.1841	-539.5	-323.5	2.3271
13	0.0498	0.0794	0.1647	-0.0015	1.55	42.17	0.5044	0.2536	0.0262	2.3271	76.82	73.96	1.2248	1.2263	-548.7	-329.1	2.3271

TO/TO INLET	PO/PO INLET	EFF-AD INLET %	EFF-P INLET %	WC1/A1 KG/SEC SQM
1.3097	2.3400	88.38	89.67	188.86

TO2/TO1	PO2/PO1	EFF-AD ROTOR %	EFF-P ROTOR %
1.3097	2.3400	88.38	89.67

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APPENDIX C
BLADE AIRFOIL GEOMETRY – REDESIGNED ROTOR

		ROOT INCHES	ROOT METERS	TIP INCHES	TIP METERS
INLET	DIAMETER =	16.50	0.419	33.10	0.841
EXIT	DIAMETER =	20.22	0.514	32.05	0.814

MULTIPLE-CIRCULAR-ARC AIRFOILS, 38 BLADES

	HUB												TIP
PERCENT FLOW	0.0	3.50	7.50	16.20	25.80	35.80	48.30	57.70	66.70	76.60	90.20	95.50	100.00
PERCENT SPAN (LE)	0.0	7.40	14.47	26.85	38.07	48.17	59.41	67.35	74.58	82.29	92.65	96.64	100.00
PERCENT SPAN (AV)	0.0	6.07	12.03	23.15	33.87	43.88	55.22	63.85	71.58	79.92	91.29	95.90	100.00
PERCENT SPAN (TE)	0.0	4.74	9.60	19.44	29.58	39.60	51.51	60.34	68.58	77.55	89.94	95.16	100.00

U.S. CUSTOMARY UNITS (inches and degrees)

c	3.9000	3.8250	3.7510	3.6530	3.6340	3.6470	3.6790	3.7220	3.7820	3.8810	4.1210	4.2660	4.4120
c_f	1.0550	1.1250	1.1940	1.3160	1.4310	1.5380	1.6670	1.7650	1.8600	1.96[illegible]	2.1000	2.1530	2.1900
t/c	0.0800	0.0768	0.0734	0.0659	0.0542	0.0478	0.0433	0.0404	0.0376	0.0324	0.0277	0.0257	0.0235
%c to max. t	53.6600	53.9770	54.2820	54.8210	55.3120	55.7550	56.2490	56.5930	56.9070	57.2400	57.6840	57.8560	58.0000
a/c	0.5229	0.5224	0.5194	0.5237	0.5468	0.5692	0.5898	0.5658	0.5957	0.6397	0.6561	0.6662	0.6653
RLE	0.0118	0.0112	0.0107	0.0099	0.0092	0.0086	0.0081	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080
RTE	0.0103	0.0100	0.0098	0.0093	0.0088	0.0084	0.0081	0.0080	0.0080	0.0080	0.0080	0.0080	0.0080
β_1^{*m}	60.2700	60.2400	60.0700	59.5700	58.7100	58.6000	59.1400	59.9400	60.9100	62.0900	63.7100	64.5700	65.6300
β_1^{*}	65.1700	65.0600	64.8700	64.1600	62.6400	62.1700	62.4700	63.1000	63.8900	64.6400	65.8300	66.4900	67.3200
ϕ	57.6600	49.7800	40.8100	29.2100	20.5600	14.7400	9.4000	6.1300	4.1400	3.2400	2.8700	3.4000	4.8000
ϕ_E	49.3600	42.4300	34.4300	24.7100	17.7500	13.4000	9.5700	7.2700	6.1600	6.1900	7.0500	7.9800	9.5600
ϕ_f	9.2900	9.9700	10.2200	8.3500	4.8300	2.4600	0.8220	1.4300	0.0410	-2.1400	-3.9900	-5.8800	-7.3600
ϕ_{E_f}	5.7600	6.8900	7.5800	6.4500	3.6200	1.8600	0.9020	1.9800	1.0400	-0.6400	-1.8700	-3.5700	-5.0000
ϵ	36.3000	31.5000	26.8700	18.8500	11.7900	5.7000	-0.7370	-5.0100	-8.8700	-12.9100	-17.8500	-19.1000	-19.2900
σ	2.5[illegible]7	2.4096	2.2594	2.0362	1.8911	1.7867	1.6389	1.6353	1.5982	1.5753	1.5878	1.6106	1.6369
s/c	0.3884	0.4150	0.4426	0.4911	0.5288	0.5597	0.5921	0.6115	0.6257	0.6348	0.6298	0.6209	0.6109

S.I. UNITS (meters and radians)

c	0.0991	0.0972	0.0953	0.0928	0.0923	0.0920	0.0934	0.0945	0.0961	0.0986	0.1047	0.1084	0.1121
c_f	0.0268	0.0286	0.0303	0.0334	0.0363	0.0391	0.0423	0.0448	0.0472	0.0499	0.0533	0.0547	0.0555
t/c	0.0800	0.0768	0.0734	0.0659	0.0542	0.0478	0.0433	0.0404	0.0376	0.0324	0.0277	0.0257	0.0235
%c to max. t	53.6600	53.9770	54.2820	54.8210	55.3120	55.7550	56.2490	56.5930	56.9070	57.2400	57.6840	57.8550	58.0000
a/c	0.5229	0.5224	0.5194	0.5237	0.5468	0.5692	0.5898	0.5658	0.5957	0.6397	0.6561	0.6662	0.6653
RLE (cm)	0.0300	0.0284	0.0272	0.0251	0.0234	0.0218	0.0206	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203
RTE (cm)	0.0262	0.0254	0.0249	0.0236	0.0224	0.0213	0.0206	0.0203	0.0203	0.0203	0.0203	0.0203	0.0203
β_1^{*m}	1.0519	1.0514	1.0484	1.0397	1.0247	1.0228	1.0322	1.0461	1.0631	1.0837	1.1119	1.1270	1.1455
β_1^{*}	1.1374	1.1355	1.1322	1.1198	1.0933	1.0851	1.0903	1.1013	1.1151	1.1282	1.1489	1.1605	1.1750
ϕ	1.0064	0.8688	0.7123	0.5098	0.3588	0.2573	0.1641	0.1070	0.0723	0.0565	0.0501	0.0593	0.0838
ϕ_E	0.8615	0.7405	0.6009	0.4313	0.3098	0.2339	0.1670	0.1269	0.1075	0.1080	0.1230	0.1393	0.1659
ϕ_f	0.1621	0.1743	0.1784	0.1457	0.0843	0.0429	0.0143	0.0250	0.0007	-0.0374	-0.0696	-0.1026	-0.1285
ϕ_{E_f}	0.1005	0.1203	0.1323	0.1126	0.0632	0.0325	0.0157	0.0346	0.0182	-0.0112	-0.0326	-0.0623	-0.0873
ϵ	0.6336	0.5498	0.4690	0.3290	0.2058	0.0995	-0.0129	-0.0874	-0.1548	-0.2253	-0.3115	-0.3334	-0.3367
σ	2.5747	2.4096	2.2594	2.0362	1.8911	1.7867	1.6889	1.6353	1.5982	1.5753	1.5878	1.6106	1.6369
s/c	0.3884	0.4150	0.4426	0.4911	0.5288	0.5597	0.5921	0.6115	0.6257	0.6348	0.6298	0.6209	0.6109

MCA airfoil definitions shown in Figure 14.
Angle definitions shown in Figure 25.

APPENDIX D
MANUFACTURING COORDINATES ON PLANES NORMAL TO THE STACKING LINE FOR THE REDESIGNED ROTOR

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0003	0.0003	0.0	-0.0105	0.0118
0.0003	-0.0002	0.0004	0.0101	-0.0071	0.0172
0.0025	0.0006	0.0016	0.0984	0.0224	0.0648
0.0050	0.0014	0.0030	0.1967	0.0542	0.1176
0.0075	0.0021	0.0043	0.2951	0.0846	0.1686
0.0100	0.0029	0.0055	0.3934	0.1138	0.2179
0.0125	0.0036	0.0068	0.4918	0.1416	0.2666
0.0150	0.0043	0.0080	0.5901	0.1685	0.3148
0.0175	0.0049	0.0092	0.6885	0.1944	0.3618
0.0200	0.0056	0.0103	0.7868	0.2189	0.4063
0.0225	0.0061	0.0114	0.8852	0.2418	0.4492
0.0250	0.0067	0.0125	0.9835	0.2630	0.4906
0.0275	0.0072	0.0134	1.0819	0.2819	0.5264
0.0300	0.0076	0.0142	1.1803	0.2986	0.5580
0.0325	0.0079	0.0149	1.2786	0.3126	0.5866
0.0350	0.0082	0.0155	1.3770	0.3246	0.6106
0.0375	0.0085	0.0160	1.4753	0.3341	0.6315
0.0400	0.0087	0.0164	1.5737	0.3411	0.6473
0.0425	0.0088	0.0167	1.6720	0.3454	0.6593
0.0450	0.0088	0.0169	1.7704	0.3466	0.6670
0.0475	0.0088	0.0171	1.8687	0.3454	0.6716
0.0500	0.0087	0.0171	1.9671	0.3419	0.6719
0.0525	0.0085	0.0169	2.0655	0.3345	0.6670
0.0550	0.0082	0.0167	2.1638	0.3232	0.6566
0.0575	0.0078	0.0163	2.2622	0.3088	0.6402
0.0600	0.0074	0.0157	2.3605	0.2902	0.6195
0.0625	0.0068	0.0150	2.4589	0.2668	0.5910
0.0650	0.0060	0.0140	2.5572	0.2379	0.5527
0.0675	0.0051	0.0128	2.6556	0.2025	0.5046
0.0700	0.0041	0.0112	2.7539	0.1605	0.4429
0.0724	0.0028	0.0092	2.8523	0.1086	0.3635
0.0749	0.0011	0.0063	2.9507	0.0427	0.2481
0.0769	-0.0005	0.0029	3.0257	-0.0193	0.1138
0.0774	-0.0010	0.0018	3.0490	-0.0386	0.0721

RADIUS (METERS) = 0.2028	RADIUS (INCHES) = 7.984
CHORD (METERS) = 0.0774	CHORD (INCHES) = 3.0490
ZCSL (METERS) = 0.0451	ZCSL (INCHES) = 1.7747
YCSL (METERS) = 0.0107	YCSL (INCHES) = 0.4211
RLE (METERS) =0.000282	RLE (INCHES) = 0.0111
RTE (METERS) =0.001010	RTE (INCHES) = 0.0398
X-AREA(SQ.METERS)=0.000470	X-AREA (SQ. IN.) = 0.7290
GAMMA-CHORD(DEG.)= 37.42	GAMMA-CHORD(RAD.)= 0.6531

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0003	0.0003	0.0	-0.0101	0.0111
0.0002	-0.0002	0.0004	0.0096	-0.0068	0.0163
0.0026	0.0006	0.0017	0.1023	0.0247	0.0662
0.0052	0.0015	0.0031	0.2047	0.0589	0.1207
0.0078	0.0023	0.0044	0.3070	0.0915	0.1733
0.0104	0.0031	0.0057	0.4094	0.1227	0.2241
0.0130	0.0039	0.0069	0.5117	0.1523	0.2733
0.0156	0.0046	0.0082	0.6140	0.1806	0.3209
0.0182	0.0053	0.0093	0.7164	0.2074	0.3670
0.0208	0.0059	0.0105	0.8187	0.2330	0.4118
0.0234	0.0065	0.0116	0.9211	0.2563	0.4549
0.0260	0.0070	0.0126	1.0234	0.2759	0.4953
0.0286	0.0074	0.0135	1.1257	0.2924	0.5298
0.0312	0.0078	0.0142	1.2281	0.3071	0.5590
0.0338	0.0081	0.0148	1.3304	0.3194	0.5837
0.0364	0.0084	0.0154	1.4328	0.3296	0.6047
0.0390	0.0086	0.0158	1.5351	0.3374	0.6220
0.0416	0.0087	0.0161	1.6375	0.3428	0.6352
0.0442	0.0088	0.0164	1.7398	0.3456	0.6442
0.0468	0.0088	0.0165	1.8421	0.3457	0.6493
0.0494	0.0087	0.0165	1.9445	0.3433	0.6503
0.0520	0.0086	0.0164	2.0468	0.3384	0.6472
0.0546	0.0084	0.0162	2.1492	0.3299	0.6390
0.0572	0.0081	0.0159	2.2515	0.3182	0.6256
0.0598	0.0077	0.0154	2.3538	0.3032	0.6071
0.0624	0.0072	0.0148	2.4562	0.2843	0.5830
0.0650	0.0066	0.0140	2.5585	0.2610	0.5510
0.0676	0.0059	0.0130	2.6609	0.2328	0.5109
0.0702	0.0051	0.0117	2.7632	0.1989	0.4608
0.0728	0.0040	0.0101	2.8655	0.1589	0.3983
0.0754	0.0028	0.0080	2.9679	0.1096	0.3165
0.0780	0.0013	0.0053	3.0702	0.0501	0.2069
0.0802	-0.0003	0.0017	3.1562	-0.0120	0.0670
0.0806	-0.0006	0.0010	3.1726	-0.0238	0.0403

RADIUS (METERS) = 0.2206	RADIUS (INCHES) = 8.684
CHORD (METERS) = 0.0806	CHORD (INCHES) = 3.1726
ZCSL (METERS) = 0.0460	ZCSL (INCHES) = 1.8122
YCSL (METERS) = 0.0101	YCSL (INCHES) = 0.3974
RLE (METERS) =0.000267	RLE (INCHES) = 0.0105
RTE (METERS) =0.000638	RTE (INCHES) = 0.0251
X-AREA(SQ.METERS)=0.000452	X-AREA (SQ. IN.) = 0.7002
GAMMA-CHORD(DEG.)= 37.83	GAMMA-CHORD(RAD.)= 0.6602

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0003	0.0	-0.0096	0.0105
0.0002	-0.0002	0.0004	0.0092	-0.0066	0.0153
0.0027	0.0006	0.0017	0.1050	0.0245	0.0655
0.0053	0.0015	0.0030	0.2100	0.0576	0.1190
0.0080	0.0023	0.0043	0.3150	0.0891	0.1702
0.0107	0.0030	0.0056	0.4200	0.1191	0.2194
0.0133	0.0037	0.0068	0.5250	0.1474	0.2666
0.0160	0.0044	0.0079	0.6300	0.1743	0.3119
0.0187	0.0051	0.0090	0.7350	0.1995	0.3554
0.0213	0.0057	0.0101	0.8400	0.2233	0.3976
0.0240	0.0062	0.0111	0.9450	0.2456	0.4380
0.0267	0.0068	0.0121	1.0500	0.2667	0.4756
0.0293	0.0073	0.0130	1.1550	0.2860	0.5100
0.0320	0.0077	0.0137	1.2600	0.3031	0.5410
0.0347	0.0081	0.0144	1.3650	0.3179	0.5677
0.0373	0.0084	0.0150	1.4700	0.3301	0.5905
0.0400	0.0086	0.0155	1.5750	0.3396	0.6089
0.0427	0.0088	0.0158	1.6800	0.3460	0.6231
0.0453	0.0089	0.0161	1.7850	0.3490	0.6328
0.0480	0.0088	0.0162	1.8900	0.3479	0.6378
0.0507	0.0087	0.0162	1.9950	0.3439	0.6376
0.0533	0.0086	0.0160	2.1000	0.3374	0.6317
0.0560	0.0083	0.0158	2.2050	0.3278	0.6211
0.0587	0.0080	0.0154	2.3100	0.3152	0.6054
0.0613	0.0076	0.0148	2.4150	0.2993	0.5846
0.0640	0.0071	0.0142	2.5200	0.2797	0.5579
0.0667	0.0065	0.0133	2.6250	0.2561	0.5240
0.0693	0.0058	0.0123	2.7300	0.2279	0.4825
0.0720	0.0049	0.0110	2.8350	0.1947	0.4313
0.0747	0.0040	0.0094	2.9400	0.1556	0.3683
0.0773	0.0028	0.0073	3.0450	0.1083	0.2873
0.0800	0.0013	0.0046	3.1500	0.0525	0.1820
0.0824	-0.0002	0.0011	3.2428	-0.0083	0.0446
0.0827	-0.0004	0.0007	3.2550	-0.0163	0.0265

RADIUS (METERS) = 0.2323	RADIUS (INCHES) = 9.144
CHORD (METERS) = 0.0827	CHORD (INCHES) = 3.2550
ZCSL (METERS) = 0.0466	ZCSL (INCHES) = 1.8356
YCSL (METERS) = 0.0098	YCSL (INCHES) = 0.3851
RLE (METERS) =0.000256	RLE (INCHES) = 0.0101
RTE (METERS) =0.000451	RTE (INCHES) = 0.0177
X-AREA(SQ.METERS)=0.000436	X-AREA (SQ. IN.) = 0.6751
GAMMA-CHORD(DEG.)= 38.43	GAMMA-CHORD(RAD.)= 0.6707

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0003	0.0	-0.0095	0.0103
0.0002	-0.0002	0.0004	0.0092	-0.0067	0.0150
0.0027	0.0006	0.0016	0.1074	0.0236	0.0641
0.0055	0.0014	0.0030	0.2147	0.0558	0.1167
0.0082	0.0022	0.0042	0.3221	0.0866	0.1669
0.0109	0.0029	0.0055	0.4295	0.1160	0.2152
0.0136	0.0037	0.0066	0.5368	0.1438	0.2613
0.0164	0.0043	0.0078	0.6442	0.1702	0.3054
0.0191	0.0050	0.0088	0.7516	0.1950	0.3476
0.0218	0.0055	0.0098	0.8589	0.2178	0.3878
0.0245	0.0061	0.0108	0.9663	0.2389	0.4257
0.0273	0.0066	0.0117	1.0737	0.2584	0.4617
0.0300	0.0070	0.0126	1.1810	0.2763	0.4946
0.0327	0.0074	0.0133	1.2884	0.2924	0.5237
0.0355	0.0078	0.0139	1.3958	0.3068	0.5491
0.0382	0.0081	0.0145	1.5031	0.3191	0.5706
0.0409	0.0084	0.0149	1.6105	0.3293	0.5884
0.0436	0.0086	0.0153	1.7179	0.3372	0.6022
0.0464	0.0087	0.0155	1.8252	0.3425	0.6120
0.0491	0.0088	0.0157	1.9326	0.3450	0.6174
0.0518	0.0087	0.0157	2.0400	0.3443	0.6185
0.0545	0.0086	0.0156	2.1474	0.3401	0.6147
0.0573	0.0084	0.0154	2.2547	0.3318	0.6057
0.0600	0.0081	0.0150	2.3621	0.3186	0.5909
0.0627	0.0076	0.0145	2.4695	0.2997	0.5695
0.0655	0.0070	0.0137	2.5768	0.2740	0.5402
0.0682	0.0063	0.0127	2.6842	0.2490	0.5012
0.0709	0.0056	0.0115	2.7916	0.2207	0.4520
0.0736	0.0048	0.0102	2.8989	0.1876	0.4001
0.0764	0.0038	0.0086	3.0063	0.1491	0.3368
0.0791	0.0026	0.0066	3.1137	0.1039	0.2581
0.0818	0.0013	0.0040	3.2210	0.0511	0.1577
0.0843	-0.0002	0.0008	3.3188	-0.0063	0.0304
0.0845	-0.0003	0.0005	3.3284	-0.0120	0.0179

RADIUS (METERS) = 0.2437	RADIUS (INCHES) = 9.594
CHORD (METERS) = 0.0845	CHORD (INCHES) = 3.3294
ZCSL (METERS) = 0.0469	ZCSL (INCHES) = 1.8480
YCSL (METERS) = 0.0096	YCSL (INCHES) = 0.3763
RLE (METERS) =0.000254	RLE (INCHES) = 0.0100
RTE (METERS) =0.000334	RTE (INCHES) = 0.0131
X-AREA(SQ.METERS)=0.000421	X-AREA (SQ. IN.) = 0.6520
GAMMA-CHORD(DEG.)= 39.30	GAMMA-CHORD(RAD.)= 0.6859

MANUFACTURING COORDINATES (Cont'd)

METERS ZC	METERS YP	METERS YS	INCHES ZC	INCHES YP	INCHES YS
0.0	-0.0002	0.0003	0.0	-0.0093	0.0101
0.0002	-0.0002	0.0004	0.0092	-0.0067	0.0144
0.0028	0.0006	0.0016	0.1097	0.0217	0.0613
0.0056	0.0013	0.0028	0.2194	0.0518	0.1114
0.0084	0.0020	0.0040	0.3292	0.0806	0.1594
0.0111	0.0027	0.0052	0.4389	0.1081	0.2054
0.0139	0.0034	0.0063	0.5486	0.1343	0.2495
0.0167	0.0040	0.0074	0.6584	0.1589	0.2915
0.0195	0.0046	0.0084	0.7681	0.1821	0.3315
0.0223	0.0052	0.0094	0.8778	0.2038	0.3695
0.0251	0.0057	0.0103	0.9875	0.2240	0.4058
0.0279	0.0062	0.0112	1.0973	0.2426	0.4400
0.0307	0.0066	0.0120	1.2070	0.2598	0.4714
0.0334	0.0070	0.0127	1.3167	0.2755	0.4997
0.0362	0.0074	0.0133	1.4264	0.2896	0.5242
0.0390	0.0077	0.0138	1.5362	0.3022	0.5452
0.0418	0.0080	0.0143	1.6459	0.3132	0.5626
0.0446	0.0082	0.0146	1.7556	0.3225	0.5764
0.0474	0.0084	0.0149	1.8654	0.3300	0.5864
0.0502	0.0085	0.0151	1.9751	0.3354	0.5927
0.0530	0.0086	0.0151	2.0848	0.3381	0.5951
0.0557	0.0086	0.0151	2.1945	0.3382	0.5934
0.0585	0.0085	0.0149	2.3043	0.3356	0.5870
0.0613	0.0084	0.0146	2.4140	0.3297	0.5758
0.0641	0.0081	0.0142	2.5237	0.3201	0.5593
0.0669	0.0078	0.0136	2.6334	0.3062	0.5367
0.0697	0.0073	0.0129	2.7432	0.2872	0.5073
0.0725	0.0066	0.0119	2.8529	0.2617	0.4697
0.0753	0.0058	0.0107	2.9626	0.2283	0.4215
0.0780	0.0047	0.0091	3.0723	0.1849	0.3593
0.0808	0.0032	0.0070	3.1821	0.1266	0.2766
0.0836	0.0012	0.0040	3.2918	0.0484	0.1556
0.0862	-0.0001	0.0006	3.3930	-0.0055	0.0248
0.0864	-0.0003	0.0004	3.4015	-0.0100	0.0139

RADIUS (METERS) = 0.2551 RADIUS (INCHES) = 10.044
CHORD (METERS) = 0.0864 CHORD (INCHES) = 3.4015
ZCSL (METERS) = 0.0471 ZCSL (INCHES) = 1.8562
YCSL (METERS) = 0.0094 YCSL (INCHES) = 0.3682
RLE (METERS) =0.000251 RLE (INCHES) = 0.0099
RTE (METERS) =0.000279 RTE (INCHES) = 0.0110
X-AREA(SQ.METERS)=0.000404 X-AREA (SQ. IN.) = 0.6263
GAMMA-CHORD(DEG.)= 40.41 GAMMA-CHORD(RAD.)= 0.7053

METERS ZC	METERS YP	METERS YS	INCHES ZC	INCHES YP	INCHES YS
0.0	-0.0002	0.0003	0.0	-0.0092	0.0099
0.0002	-0.0002	0.0004	0.0092	-0.0069	0.0139
0.0028	0.0005	0.0015	0.1112	0.0192	0.0581
0.0056	0.0012	0.0027	0.2224	0.0467	0.1051
0.0085	0.0019	0.0038	0.3336	0.0730	0.1502
0.0113	0.0025	0.0049	0.4448	0.0980	0.1934
0.0141	0.0031	0.0060	0.5560	0.1218	0.2348
0.0169	0.0037	0.0070	0.6673	0.1442	0.2742
0.0198	0.0042	0.0079	0.7785	0.1652	0.3117
0.0226	0.0047	0.0088	0.8897	0.1848	0.3473
0.0254	0.0052	0.0097	1.0009	0.2029	0.3811
0.0282	0.0056	0.0105	1.1121	0.2194	0.4128
0.0311	0.0060	0.0112	1.2233	0.2345	0.4421
0.0339	0.0063	0.0119	1.3345	0.2481	0.4683
0.0367	0.0066	0.0125	1.4457	0.2603	0.4909
0.0395	0.0069	0.0130	1.5569	0.2710	0.5099
0.0424	0.0071	0.0133	1.6681	0.2803	0.5254
0.0452	0.0073	0.0137	1.7794	0.2878	0.5374
0.0480	0.0075	0.0139	1.8906	0.2936	0.5457
0.0508	0.0076	0.0140	2.0018	0.2977	0.5503
0.0537	0.0076	0.0140	2.1130	0.2999	0.5512
0.0565	0.0076	0.0139	2.2242	0.3000	0.5480
0.0593	0.0076	0.0137	2.3354	0.2979	0.5407
0.0621	0.0075	0.0134	2.4466	0.2934	0.5290
0.0650	0.0072	0.0130	2.5578	0.2854	0.5126
0.0678	0.0069	0.0125	2.6690	0.2735	0.4911
0.0706	0.0065	0.0118	2.7803	0.2577	0.4631
0.0734	0.0060	0.0109	2.8915	0.2371	0.4277
0.0763	0.0053	0.0097	3.0027	0.2103	0.3836
0.0791	0.0045	0.0083	3.1139	0.1758	0.3282
0.0819	0.0033	0.0065	3.2251	0.1304	0.2572
0.0847	0.0018	0.0041	3.3363	0.0705	0.1614
0.0874	-0.0002	0.0007	3.4393	-0.0062	0.0278
0.0876	-0.0003	0.0004	3.4475	-0.0123	0.0171

RADIUS (METERS) = 0.2600 RADIUS (INCHES) = 10.235
CHORD (METERS) = 0.0876 CHORD (INCHES) = 3.4475
ZCSL (METERS) = 0.0473 ZCSL (INCHES) = 1.8641
YCSL (METERS) = 0.0086 YCSL (INCHES) = 0.3367
RLE (METERS) =0.000248 RLE (INCHES) = 0.0098
RTE (METERS) =0.000299 RTE (INCHES) = 0.0118
X-AREA(SQ.METERS)=0.000394 X-AREA (SQ. IN.) = 0.6107
GAMMA-CHORD(DEG.)= 41.83 GAMMA-CHORD(RAD.)= 0.7301

METERS ZC	METERS YP	METERS YS	INCHES ZC	INCHES YP	INCHES YS
0.0	-0.0002	0.0002	0.0	-0.0091	0.0097
0.0002	-0.0002	0.0003	0.0093	-0.0071	0.0133
0.0029	0.0004	0.0013	0.1124	0.0152	0.0531
0.0057	0.0010	0.0024	0.2249	0.0387	0.0955
0.0086	0.0016	0.0035	0.3374	0.0611	0.1363
0.0114	0.0021	0.0045	0.4498	0.0823	0.1752
0.0143	0.0026	0.0054	0.5623	0.1022	0.2122
0.0171	0.0031	0.0063	0.6747	0.1210	0.2475
0.0200	0.0035	0.0071	0.7872	0.1384	0.2808
0.0229	0.0039	0.0079	0.8996	0.1546	0.3125
0.0257	0.0043	0.0087	1.0121	0.1693	0.3424
0.0286	0.0046	0.0094	1.1245	0.1826	0.3703
0.0314	0.0049	0.0101	1.2370	0.1945	0.3961
0.0343	0.0052	0.0106	1.3494	0.2049	0.4191
0.0371	0.0054	0.0111	1.4619	0.2140	0.4386
0.0400	0.0056	0.0115	1.5743	0.2216	0.4547
0.0428	0.0058	0.0119	1.6868	0.2278	0.4673
0.0457	0.0059	0.0121	1.7992	0.2324	0.4764
0.0486	0.0060	0.0122	1.9117	0.2355	0.4820
0.0514	0.0060	0.0123	2.0241	0.2370	0.4839
0.0543	0.0060	0.0122	2.1366	0.2367	0.4821
0.0571	0.0060	0.0121	2.2490	0.2346	0.4765
0.0600	0.0059	0.0119	2.3615	0.2304	0.4670
0.0628	0.0057	0.0115	2.4739	0.2241	0.4532
0.0657	0.0055	0.0110	2.5864	0.2155	0.4350
0.0686	0.0052	0.0105	2.6988	0.2043	0.4119
0.0714	0.0048	0.0097	2.8113	0.1902	0.3834
0.0743	0.0044	0.0089	2.9237	0.1729	0.3490
0.0771	0.0039	0.0078	3.0362	0.1517	0.3079
0.0800	0.0031	0.0066	3.1486	0.1240	0.2585
0.0828	0.0023	0.0050	3.2611	0.0895	0.1966
0.0857	0.0012	0.0030	3.3736	0.0460	0.1181
0.0883	-0.0002	0.0005	3.4770	-0.0059	0.0215
0.0885	-0.0003	0.0003	3.4860	-0.0104	0.0131

RADIUS (METERS) = 0.2650 RADIUS (INCHES) = 10.434
CHORD (METERS) = 0.0885 CHORD (INCHES) = 3.4860
ZCSL (METERS) = 0.0476 ZCSL (INCHES) = 1.8732
YCSL (METERS) = 0.0072 YCSL (INCHES) = 0.2831
RLE (METERS) =0.000248 RLE (INCHES) = 0.0098
RTE (METERS) =0.000280 RTE (INCHES) = 0.0110
X-AREA(SQ.METERS)=0.000382 X-AREA (SQ. IN.) = 0.5916
GAMMA-CHORD(DEG.)= 43.93 GAMMA-CHORD(RAD.)= 0.7667

METERS ZC	METERS YP	METERS YS	INCHES ZC	INCHES YP	INCHES YS
0.0	-0.0002	0.0002	0.0	-0.0090	0.0096
0.0002	-0.0002	0.0003	0.0093	-0.0072	0.0130
0.0029	0.0003	0.0013	0.1129	0.0129	0.0502
0.0057	0.0009	0.0023	0.2257	0.0341	0.0897
0.0086	0.0014	0.0032	0.3386	0.0544	0.1278
0.0115	0.0019	0.0042	0.4514	0.0737	0.1643
0.0143	0.0023	0.0051	0.5643	0.0919	0.1992
0.0172	0.0028	0.0059	0.6771	0.1090	0.2326
0.0201	0.0032	0.0067	0.7900	0.1247	0.2642
0.0229	0.0035	0.0075	0.9028	0.1392	0.2940
0.0258	0.0039	0.0082	1.0157	0.1523	0.3220
0.0287	0.0042	0.0088	1.1286	0.1640	0.3480
0.0315	0.0044	0.0095	1.2414	0.1744	0.3721
0.0344	0.0047	0.0100	1.3543	0.1834	0.3935
0.0373	0.0049	0.0105	1.4671	0.1910	0.4116
0.0401	0.0050	0.0108	1.5800	0.1973	0.4263
0.0430	0.0051	0.0111	1.6928	0.2022	0.4376
0.0459	0.0052	0.0113	1.8057	0.2057	0.4455
0.0487	0.0053	0.0114	1.9186	0.2076	0.4500
0.0516	0.0053	0.0115	2.0314	0.2080	0.4509
0.0545	0.0052	0.0114	2.1443	0.2067	0.4482
0.0573	0.0052	0.0112	2.2571	0.2036	0.4417
0.0602	0.0050	0.0110	2.3700	0.1987	0.4314
0.0631	0.0049	0.0106	2.4828	0.1918	0.4169
0.0659	0.0046	0.0101	2.5957	0.1829	0.3981
0.0688	0.0044	0.0095	2.7085	0.1716	0.3748
0.0717	0.0040	0.0088	2.8214	0.1577	0.3464
0.0745	0.0036	0.0079	2.9343	0.1409	0.3123
0.0774	0.0031	0.0069	3.0471	0.1210	0.2720
0.0803	0.0025	0.0057	3.1600	0.0973	0.2243
0.0831	0.0018	0.0043	3.2728	0.0693	0.1677
0.0860	0.0009	0.0025	3.3857	0.0346	0.0999
0.0886	-0.0002	0.0005	3.4893	-0.0061	0.0189
0.0889	-0.0002	0.0003	3.4985	-0.0097	0.0117

RADIUS (METERS) = 0.2681 RADIUS (INCHES) = 10.554
CHORD (METERS) = 0.0889 CHORD (INCHES) = 3.4985
ZCSL (METERS) = 0.0477 ZCSL (INCHES) = 1.8766
YCSL (METERS) = 0.0065 YCSL (INCHES) = 0.2572
RLE (METERS) =0,000247 RLE (INCHES) = 0.0097
RTE (METERS) =0.000271 RTE (INCHES) = 0.0106
X-AREA(SQ.METERS)=0.000374 X-AREA (SQ. IN.) = 0.5801
GAMMA-CHORD(DEG.)= 45.00 GAMMA-CHORD(RAD.)= 0.7854

MANUFACTURING COORDINATES (Cont'd)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0090	0.0096
0.0002	-0.0002	0.0003	0.0093	-0.0073	0.0129
0.0029	0.0003	0.0013	0.1129	0.0123	0.0495
0.0057	0.0008	0.0022	0.2259	0.0331	0.0884
0.0086	0.0013	0.0032	0.3388	0.0529	0.1258
0.0115	0.0018	0.0041	0.4517	0.0718	0.1618
0.0143	0.0023	0.0050	0.5647	0.0895	0.1961
0.0172	0.0027	0.0058	0.6776	0.1062	0.2290
0.0201	0.0031	0.0066	0.7906	0.1216	0.2600
0.0229	0.0034	0.0074	0.9035	0.1358	0.2895
0.0258	0.0038	0.0081	1.0164	0.1485	0.3173
0.0287	0.0041	0.0087	1.1294	0.1600	0.3429
0.0316	0.0043	0.0093	1.2423	0.1700	0.3667
0.0344	0.0045	0.0098	1.3553	0.1787	0.3878
0.0373	0.0047	0.0103	1.4682	0.1861	0.4056
0.0402	0.0049	0.0107	1.5811	0.1921	0.4200
0.0430	0.0050	0.0109	1.6941	0.1967	0.4310
0.0459	0.0051	0.0111	1.8070	0.1999	0.4387
0.0488	0.0051	0.0113	1.9199	0.2016	0.4430
0.0516	0.0051	0.0113	2.0329	0.2018	0.4437
0.0545	0.0051	0.0112	2.1458	0.2004	0.4408
0.0574	0.0050	0.0110	2.2588	0.1971	0.4342
0.0602	0.0049	0.0108	2.3717	0.1921	0.4237
0.0631	0.0047	0.0104	2.4846	0.1851	0.4092
0.0660	0.0045	0.0099	2.5976	0.1761	0.3904
0.0688	0.0042	0.0093	2.7105	0.1649	0.3670
0.0717	0.0038	0.0086	2.8235	0.1511	0.3387
0.0746	0.0034	0.0077	2.9364	0.1345	0.3048
0.0775	0.0029	0.0067	3.0493	0.1149	0.2647
0.0803	0.0023	0.0055	3.1623	0.0917	0.2175
0.0832	0.0016	0.0041	3.2752	0.0642	0.1616
0.0861	0.0008	0.0024	3.3881	0.0318	0.0949
0.0887	-0.0002	0.0005	3.4918	-0.0061	0.0183
0.0889	-0.0002	0.0003	3.5011	-0.0095	0.0114

RADIUS (METERS) = 0.2688 RADIUS (INCHES) = 10.584
CHORD (METERS) = 0.0889 CHORD (INCHES) = 3.5011
ZCSL (METERS) = 0.0477 ZCSL (INCHES) = 1.8773
YCSL (METERS) = 0.0064 YCSL (INCHES) = 0.2516
RLE (METERS) =0.000247 RLE (INCHES) = 0.0097
RTE (METERS) =0.000269 RTE (INCHES) = 0.0106
X-AREA(SQ.METERS)=0.000372 X-AREA (SQ. IN.) = 0.5772
GAMMA-CHORD(DEG.)= 45.24 GAMMA-CHORD(RAD.)= 0.7896

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0090	0.0094
0.0002	-0.0002	0.0003	0.0093	-0.0074	0.0125
0.0029	0.0003	0.0012	0.1133	0.0102	0.0465
0.0058	0.0007	0.0021	0.2265	0.0289	0.0829
0.0086	0.0012	0.0030	0.3398	0.0468	0.1177
0.0115	0.0016	0.0038	0.4531	0.0638	0.1512
0.0144	0.0020	0.0047	0.5663	0.0799	0.1832
0.0173	0.0024	0.0054	0.6796	0.0949	0.2138
0.0201	0.0028	0.0062	0.7929	0.1089	0.2428
0.0230	0.0031	0.0069	0.9061	0.1218	0.2703
0.0259	0.0034	0.0075	1.0194	0.1334	0.2962
0.0288	0.0037	0.0081	1.1327	0.1438	0.3205
0.0316	0.0039	0.0087	1.2460	0.1528	0.3431
0.0345	0.0041	0.0092	1.3592	0.1605	0.3632
0.0374	0.0042	0.0097	1.4725	0.1668	0.3802
0.0403	0.0044	0.0100	1.5858	0.1719	0.3940
0.0432	0.0045	0.0103	1.6990	0.1757	0.4045
0.0460	0.0045	0.0104	1.8123	0.1782	0.4114
0.0489	0.0046	0.0105	1.9256	0.1794	0.4150
0.0518	0.0045	0.0105	2.0388	0.1790	0.4152
0.0547	0.0045	0.0105	2.1521	0.1772	0.4119
0.0575	0.0044	0.0103	2.2654	0.1737	0.4051
0.0604	0.0043	0.0100	2.3786	0.1687	0.3946
0.0633	0.0041	0.0097	2.4919	0.1618	0.3801
0.0662	0.0039	0.0092	2.6052	0.1531	0.3616
0.0690	0.0036	0.0086	2.7184	0.1424	0.3388
0.0719	0.0033	0.0079	2.8317	0.1294	0.3113
0.0748	0.0029	0.0071	2.9450	0.1141	0.2787
0.0777	0.0024	0.0061	3.0583	0.0963	0.2405
0.0806	0.0019	0.0050	3.1715	0.0755	0.1959
0.0834	0.0013	0.0037	3.2848	0.0514	0.1439
0.0863	0.0006	0.0021	3.3981	0.0234	0.0828
0.0890	-0.0002	0.0004	3.5021	-0.0063	0.0164
0.0892	-0.0002	0.0003	3.5113	-0.0090	0.0105

RADIUS (METERS) = 0.2726 RADIUS (INCHES) = 10.734
CHORD (METERS) = 0.0892 CHORD (INCHES) = 3.5113
ZCSL (METERS) = 0.0477 ZCSL (INCHES) = 1.8798
YCSL (METERS) = 0.0059 YCSL (INCHES) = 0.2310
RLE (METERS) =0.000245 RLE (INCHES) = 0.0096
RTE (METERS) =0.000260 RTE (INCHES) = 0.0102
X-AREA(SQ.METERS)=0.000362 X-AREA (SQ. IN.) = 0.5618
GAMMA-CHORD(DEG.)= 46.22 GAMMA-CHORD(RAD.)= 0.8067

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0089	0.0093
0.0002	-0.0002	0.0003	0.0093	-0.0075	0.0120
0.0029	0.0002	0.0011	0.1137	0.0078	0.0431
0.0058	0.0006	0.0019	0.2273	0.0241	0.0762
0.0087	0.0010	0.0027	0.3410	0.0397	0.1080
0.0115	0.0014	0.0035	0.4546	0.0545	0.1386
0.0144	0.0017	0.0043	0.5683	0.0685	0.1678
0.0173	0.0021	0.0050	0.6819	0.0817	0.1958
0.0202	0.0024	0.0056	0.7956	0.0940	0.2223
0.0231	0.0027	0.0063	0.9093	0.1053	0.2475
0.0260	0.0029	0.0069	1.0229	0.1156	0.2712
0.0289	0.0032	0.0075	1.1366	0.1249	0.2934
0.0318	0.0034	0.0080	1.2502	0.1330	0.3141
0.0346	0.0036	0.0084	1.3639	0.1399	0.3326
0.0375	0.0037	0.0089	1.4776	0.1457	0.3486
0.0404	0.0038	0.0092	1.5912	0.1501	0.3615
0.0433	0.0039	0.0094	1.7049	0.1532	0.3712
0.0462	0.0039	0.0096	1.8185	0.1550	0.3777
0.0491	0.0040	0.0097	1.9322	0.1555	0.3810
0.0520	0.0039	0.0097	2.0458	0.1546	0.3810
0.0549	0.0039	0.0096	2.1595	0.1522	0.3778
0.0577	0.0038	0.0094	2.2732	0.1484	0.3711
0.0606	0.0036	0.0092	2.3868	0.1434	0.3609
0.0635	0.0035	0.0088	2.5005	0.1370	0.3470
0.0664	0.0033	0.0084	2.6141	0.1290	0.3292
0.0693	0.0030	0.0078	2.7278	0.1192	0.3075
0.0722	0.0027	0.0072	2.8415	0.1077	0.2815
0.0751	0.0024	0.0064	2.9551	0.0943	0.2510
0.0779	0.0020	0.0055	3.0688	0.0787	0.2155
0.0808	0.0015	0.0044	3.1824	0.0609	0.1745
0.0837	0.0010	0.0032	3.2961	0.0406	0.1272
0.0866	0.0004	0.0018	3.4097	0.0175	0.0728
0.0893	-0.0002	0.0004	3.5142	-0.0066	0.0149
0.0895	-0.0002	0.0002	3.5234	-0.0087	0.0098

RADIUS (METERS) = 0.2777 RADIUS (INCHES) = 10.934
CHORD (METERS) = 0.0895 CHORD (INCHES) = 3.5234
ZCSL (METERS) = 0.0478 ZCSL (INCHES) = 1.8830
YCSL (METERS) = 0.0053 YCSL (INCHES) = 0.2075
RLE (METERS) =0.000242 RLE (INCHES) = 0.0095
RTE (METERS) =0.000251 RTE (INCHES) = 0.0099
X-AREA(SQ.METERS)=0.000348 X-AREA (SQ. IN.) = 0.5388
GAMMA-CHORD(DEG.)= 47.40 GAMMA-CHORD(RAD.)= 0.8273

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0085	0.0088
0.0002	-0.0002	0.0003	0.0090	-0.0075	0.0111
0.0029	0.0001	0.0010	0.1145	0.0042	0.0377
0.0058	0.0004	0.0017	0.2290	0.0167	0.0660
0.0087	0.0007	0.0024	0.3434	0.0288	0.0932
0.0116	0.0010	0.0030	0.4579	0.0403	0.1193
0.0145	0.0013	0.0037	0.5724	0.0512	0.1443
0.0174	0.0016	0.0043	0.6869	0.0615	0.1683
0.0204	0.0018	0.0049	0.8014	0.0712	0.1911
0.0233	0.0020	0.0054	0.9158	0.0802	0.2126
0.0262	0.0022	0.0059	1.0303	0.0884	0.2330
0.0291	0.0024	0.0064	1.1448	0.0958	0.2522
0.0320	0.0026	0.0069	1.2593	0.1025	0.2700
0.0349	0.0028	0.0073	1.3738	0.1084	0.2863
0.0378	0.0029	0.0076	1.4882	0.1132	0.3005
0.0407	0.0030	0.0079	1.6027	0.1170	0.3120
0.0436	0.0030	0.0081	1.7172	0.1196	0.3204
0.0465	0.0031	0.0083	1.8317	0.1211	0.3260
0.0494	0.0031	0.0083	1.9462	0.1214	0.3286
0.0523	0.0031	0.0083	2.0606	0.1206	0.3283
0.0552	0.0030	0.0083	2.1751	0.1187	0.3250
0.0582	0.0029	0.0081	2.2896	0.1155	0.3187
0.0611	0.0028	0.0079	2.4041	0.1111	0.3092
0.0640	0.0027	0.0075	2.5186	0.1054	0.2966
0.0669	0.0025	0.0071	2.6330	0.0984	0.2806
0.0698	0.0023	0.0066	2.7475	0.0902	0.2612
0.0727	0.0020	0.0060	2.8620	0.0806	0.2382
0.0756	0.0018	0.0054	2.9765	0.0696	0.2114
0.0785	0.0015	0.0046	3.0910	0.0571	0.1805
0.0814	0.0011	0.0037	3.2054	0.0431	0.1453
0.0843	0.0007	0.0027	3.3199	0.0275	0.1054
0.0872	0.0003	0.0015	3.4344	0.0102	0.0602
0.0899	-0.0002	0.0003	3.5396	-0.0070	0.0134
0.0901	-0.0002	0.0002	3.5489	-0.0085	0.0092

RADIUS (METERS) = 0.2866 RADIUS (INCHES) = 11.284
CHORD (METERS) = 0.0901 CHORD (INCHES) = 3.5489
ZCSL (METERS) = 0.0480 ZCSL (INCHES) = 1.8886
YCSL (METERS) = 0.0044 YCSL (INCHES) = 0.1719
RLE (METERS) =0.000233 RLE (INCHES) = 0.0092
RTE (METERS) =0.000245 RTE (INCHES) = 0.0097
X-AREA(SQ.METERS)=0.000322 X-AREA (SQ. IN.) = 0.4987
GAMMA-CHORD(DEG.)= 49.33 GAMMA-CHORD(RAD.)= 0.8610

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MANUFACTURING COORDINATES (Cont'd)

METERS ZC	METERS YP	METERS YS	INCHES ZC	INCHES YP	INCHES YS
0.0	-0.0002	0.0002	0.0	-0.0083	0.0085
0.0002	-0.0002	0.0003	0.0088	-0.0076	0.0104
0.0029	0.0000	0.0008	0.1156	0.0010	0.0333
0.0059	0.0003	0.0015	0.2312	0.0101	0.0574
0.0088	0.0005	0.0020	0.3468	0.0189	0.0805
0.0117	0.0007	0.0026	0.4624	0.0274	0.1028
0.0147	0.0009	0.0032	0.5779	0.0355	0.1241
0.0176	0.0011	0.0037	0.6935	0.0432	0.1445
0.0206	0.0013	0.0042	0.8091	0.0505	0.1639
0.0235	0.0015	0.0046	0.9247	0.0573	0.1823
0.0264	0.0016	0.0051	1.0403	0.0637	0.1997
0.0294	0.0018	0.0055	1.1559	0.0695	0.2161
0.0323	0.0019	0.0059	1.2715	0.0748	0.2315
0.0352	0.0020	0.0062	1.3871	0.0796	0.2458
0.0382	0.0021	0.0066	1.5027	0.0837	0.2583
0.0411	0.0022	0.0068	1.6182	0.0869	0.2685
0.0440	0.0023	0.0070	1.7338	0.0892	0.2760
0.0470	0.0023	0.0071	1.8494	0.0904	0.2808
0.0499	0.0023	0.0072	1.9650	0.0908	0.2829
0.0528	0.0023	0.0072	2.0806	0.0903	0.2824
0.0558	0.0023	0.0071	2.1962	0.0888	0.2792
0.0587	0.0022	0.0069	2.3118	0.0863	0.2732
0.0617	0.0021	0.0067	2.4274	0.0828	0.2645
0.0646	0.0020	0.0064	2.5430	0.0783	0.2530
0.0675	0.0018	0.0061	2.6586	0.0728	0.2386
0.0705	0.0017	0.0056	2.7741	0.0664	0.2213
0.0734	0.0015	0.0051	2.8897	0.0589	0.2010
0.0763	0.0013	0.0045	3.0053	0.0503	0.1776
0.0793	0.0010	0.0038	3.1209	0.0408	0.1509
0.0822	0.0008	0.0031	3.2365	0.0302	0.1209
0.0851	0.0005	0.0022	3.3521	0.0184	0.0873
0.0881	0.0001	0.0013	3.4677	0.0056	0.0500
0.0908	-0.0002	0.0003	3.5743	-0.0071	0.0120
0.0910	-0.0002	0.0002	3.5833	-0.0082	0.0088

RADIUS (METERS)	= 0.2960	RADIUS (INCHES)	= 11.654
CHORD (METERS)	= 0.0910	CHORD (INCHES)	= 3.5833
ZCSL (METERS)	= 0.0481	ZCSL (INCHES)	= 1.8937
YCSL (METERS)	= 0.0036	YCSL (INCHES)	= 0.1408
RLE (METERS)	=0.000226	RLE (INCHES)	= 0.0089
RTE (METERS)	=0.000235	RTE (INCHES)	= 0.0092
X-AREA(SQ.METERS)	=0.000300	X-AREA (SQ. IN.)	= 0.4656
GAMMA-CHORD(DEG.)	= 51.10	GAMMA-CHORD(RAD.)	= 0.8919

METERS ZC	METERS YP	METERS YS	INCHES ZC	INCHES YP	INCHES YS
0.0	-0.0002	0.0002	0.0	-0.0081	0.0083
0.0002	-0.0002	0.0003	0.0086	-0.0077	0.0099
0.0030	-0.0000	0.0008	0.1164	-0.0014	0.0299
0.0059	0.0001	0.0013	0.2329	0.0052	0.0509
0.0089	0.0003	0.0018	0.3493	0.0117	0.0711
0.0118	0.0005	0.0023	0.4657	0.0180	0.0905
0.0148	0.0006	0.0028	0.5822	0.0240	0.1092
0.0177	0.0008	0.0032	0.6986	0.0298	0.1270
0.0207	0.0009	0.0037	0.8150	0.0353	0.1440
0.0237	0.0010	0.0041	0.9315	0.0406	0.1602
0.0266	0.0012	0.0045	1.0479	0.0455	0.1755
0.0296	0.0013	0.0048	1.1643	0.0502	0.1899
0.0325	0.0014	0.0052	1.2808	0.0545	0.2035
0.0355	0.0015	0.0055	1.3972	0.0584	0.2163
0.0384	0.0016	0.0058	1.5136	0.0619	0.2276
0.0414	0.0016	0.0060	1.6301	0.0649	0.2371
0.0444	0.0017	0.0062	1.7465	0.0669	0.2441
0.0473	0.0017	0.0063	1.8629	0.0681	0.2486
0.0503	0.0017	0.0064	1.9794	0.0686	0.2506
0.0532	0.0017	0.0064	2.0958	0.0683	0.2502
0.0562	0.0017	0.0063	2.2123	0.0671	0.2472
0.0591	0.0017	0.0061	2.3287	0.0652	0.2418
0.0621	0.0016	0.0059	2.4451	0.0624	0.2338
0.0651	0.0015	0.0057	2.5616	0.0588	0.2233
0.0680	0.0014	0.0053	2.6780	0.0546	0.2103
0.0710	0.0013	0.0049	2.7944	0.0494	0.1946
0.0739	0.0011	0.0045	2.9109	0.0435	0.1763
0.0769	0.0009	0.0039	3.0273	0.0368	0.1554
0.0799	0.0007	0.0033	3.1437	0.0294	0.1318
0.0828	0.0005	0.0027	3.2602	0.0211	0.1053
0.0858	0.0003	0.0019	3.3766	0.0121	0.0760
0.0887	0.0001	0.0011	3.4930	0.0023	0.0436
0.0915	-0.0002	0.0003	3.6007	-0.0072	0.0111
0.0917	-0.0002	0.0002	3.6095	-0.0080	0.0084

RADIUS (METERS)	= 0.3044	RADIUS (INCHES)	= 11.984
CHORD (METERS)	= 0.0917	CHORD (INCHES)	= 3.6095
ZCSL (METERS)	= 0.0482	ZCSL (INCHES)	= 1.8987
YCSL (METERS)	= 0.0030	YCSL (INCHES)	= 0.1188
RLE (METERS)	=0.000220	RLE (INCHES)	= 0.0087
RTE (METERS)	=0.000227	RTE (INCHES)	= 0.0089
X-AREA(SQ.METERS)	=0.000287	X-AREA (SQ. IN.)	= 0.4441
GAMMA-CHORD(DEG.)	= 52.51	GAMMA-CHORD(RAD.)	= 0.9165

METERS ZC	METERS YP	METERS YS	INCHES ZC	INCHES YP	INCHES YS
0.0	-0.0002	0.0002	0.0	-0.0078	0.0079
0.0002	-0.0002	0.0002	0.0083	-0.0077	0.0090
0.0030	-0.0002	0.0006	0.1178	-0.0060	0.0238
0.0060	-0.0001	0.0010	0.2357	-0.0040	0.0392
0.0090	-0.0001	0.0014	0.3535	-0.0021	0.0541
0.0120	-0.0000	0.0017	0.4713	-0.0000	0.0684
0.0150	0.0001	0.0021	0.5892	0.0020	0.0822
0.0180	0.0001	0.0024	0.7070	0.0041	0.0954
0.0210	0.0002	0.0027	0.8248	0.0063	0.1080
0.0239	0.0002	0.0031	0.9427	0.0084	0.1201
0.0269	0.0003	0.0033	1.0605	0.0106	0.1316
0.0299	0.0003	0.0036	1.1783	0.0129	0.1425
0.0329	0.0004	0.0039	1.2962	0.0151	0.1529
0.0359	0.0004	0.0041	1.4140	0.0173	0.1627
0.0389	0.0005	0.0044	1.5319	0.0197	0.1719
0.0419	0.0006	0.0046	1.6497	0.0219	0.1801
0.0449	0.0006	0.0047	1.7675	0.0237	0.1865
0.0479	0.0006	0.0048	1.8854	0.0250	0.1909
0.0509	0.0007	0.0049	2.0032	0.0258	0.1931
0.0539	0.0007	0.0049	2.1210	0.0261	0.1931
0.0569	0.0007	0.0049	2.2389	0.0259	0.1912
0.0599	0.0006	0.0048	2.3567	0.0252	0.1871
0.0629	0.0006	0.0046	2.4745	0.0241	0.1809
0.0658	0.0006	0.0044	2.5924	0.0225	0.1727
0.0688	0.0005	0.0041	2.7102	0.0205	0.1624
0.0718	0.0005	0.0038	2.8280	0.0181	0.1502
0.0748	0.0004	0.0035	2.9459	0.0154	0.1359
0.0778	0.0003	0.0030	3.0637	0.0123	0.1195
0.0808	0.0002	0.0026	3.1815	0.0088	0.1012
0.0838	0.0001	0.0021	3.2994	0.0050	0.0808
0.0868	0.0000	0.0015	3.4172	0.0010	0.0585
0.0898	-0.0001	0.0009	3.5350	-0.0032	0.0342
0.0926	-0.0002	0.0002	3.6446	-0.0072	0.0097
0.0928	-0.0002	0.0002	3.6529	-0.0075	0.0079

RADIUS (METERS)	= 0.3224	RADIUS (INCHES)	= 12.694
CHORD (METERS)	= 0.0928	CHORD (INCHES)	= 3.6529
ZCSL (METERS)	= 0.0485	ZCSL (INCHES)	= 1.9111
YCSL (METERS)	= 0.0020	YCSL (INCHES)	= 0.0789
RLE (METERS)	=0.000211	RLE (INCHES)	= 0.0083
RTE (METERS)	=0.000212	RTE (INCHES)	= 0.0084
X-AREA(SQ.METERS)	=0.000267	X-AREA (SQ. IN.)	= 0.4134
GAMMA-CHORD(DEG.)	= 55.35	GAMMA-CHORD(RAD.)	= 0.9660

METERS ZC	METERS YP	METERS YS	INCHES ZC	INCHES YP	INCHES YS
0.0	-0.0002	0.0002	0.0	-0.0077	0.0078
0.0002	-0.0002	0.0002	0.0082	-0.0077	0.0087
0.0030	-0.0002	0.0005	0.1185	-0.0080	0.0211
0.0060	-0.0002	0.0009	0.2369	-0.0082	0.0339
0.0090	-0.0002	0.0012	0.3554	-0.0082	0.0464
0.0120	-0.0002	0.0015	0.4739	-0.0081	0.0584
0.0150	-0.0002	0.0018	0.5923	-0.0078	0.0699
0.0181	-0.0002	0.0021	0.7108	-0.0073	0.0811
0.0211	-0.0002	0.0023	0.8292	-0.0067	0.0918
0.0241	-0.0002	0.0026	0.9477	-0.0060	0.1020
0.0271	-0.0001	0.0028	1.0662	-0.0051	0.1117
0.0301	-0.0001	0.0031	1.1846	-0.0040	0.1210
0.0331	-0.0001	0.0033	1.3031	-0.0028	0.1298
0.0361	-0.0000	0.0035	1.4216	-0.0015	0.1381
0.0391	0.0000	0.0037	1.5400	0.0001	0.1463
0.0421	0.0000	0.0039	1.6585	0.0017	0.1536
0.0451	0.0001	0.0041	1.7770	0.0032	0.1595
0.0481	0.0001	0.0042	1.8954	0.0044	0.1637
0.0512	0.0001	0.0042	2.0139	0.0052	0.1660
0.0542	0.0001	0.0042	2.1324	0.0058	0.1664
0.0572	0.0002	0.0042	2.2508	0.0061	0.1648
0.0602	0.0002	0.0041	2.3693	0.0060	0.1615
0.0632	0.0001	0.0040	2.4878	0.0057	0.1563
0.0662	0.0001	0.0038	2.6062	0.0051	0.1493
0.0692	0.0001	0.0036	2.7247	0.0042	0.1405
0.0722	0.0001	0.0033	2.8431	0.0032	0.1298
0.0752	0.0000	0.0030	2.9616	0.0019	0.1174
0.0782	0.0000	0.0026	3.0801	0.0005	0.1033
0.0812	-0.0000	0.0022	3.1985	-0.0009	0.0875
0.0843	-0.0001	0.0018	3.3170	-0.0025	0.0700
0.0873	-0.0001	0.0013	3.4355	-0.0041	0.0508
0.0903	-0.0001	0.0008	3.5539	-0.0058	0.0300
0.0931	-0.0002	0.0002	3.6643	-0.0072	0.0093
0.0933	-0.0002	0.0002	3.6724	-0.0073	0.0077

RADIUS (METERS)	= 0.3316	RADIUS (INCHES)	= 13.054
CHORD (METERS)	= 0.0933	CHORD (INCHES)	= 3.6724
ZCSL (METERS)	= 0.0487	ZCSL (INCHES)	= 1.9188
YCSL (METERS)	= 0.0015	YCSL (INCHES)	= 0.0602
RLE (METERS)	=0.000208	RLE (INCHES)	= 0.0082
RTE (METERS)	=0.000208	RTE (INCHES)	= 0.0082
X-AREA(SQ.METERS)	=0.000258	X-AREA (SQ. IN.)	= 0.3999
GAMMA-CHORD(DEG.)	= 56.63	GAMMA-CHORD(RAD.)	= 0.9884

MANUFACTURING COORDINATES (Cont'd)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0077	0.0077
0.0002	-0.0002	0.0002	0.0081	-0.0078	0.0085
0.0030	-0.0002	0.0005	0.1193	-0.0087	0.0200
0.0061	-0.0002	0.0008	0.2385	-0.0097	0.0317
0.0091	-0.0003	0.0011	0.3579	-0.0107	0.0429
0.0121	-0.0003	0.0014	0.4771	-0.0116	0.0535
0.0151	-0.0003	0.0016	0.5964	-0.0125	0.0636
0.0182	-0.0003	0.0019	0.7156	-0.0134	0.0730
0.0212	-0.0004	0.0021	0.8349	-0.0142	0.0819
0.0242	-0.0004	0.0023	0.9542	-0.0149	0.0903
0.0273	-0.0004	0.0025	1.0735	-0.0155	0.0981
0.0303	-0.0004	0.0027	1.1927	-0.0161	0.1054
0.0333	-0.0004	0.0028	1.3120	-0.0166	0.1121
0.0364	-0.0004	0.0030	1.4313	-0.0169	0.1183
0.0394	-0.0004	0.0032	1.5506	-0.0172	0.1241
0.0424	-0.0004	0.0033	1.6698	-0.0174	0.1292
0.0454	-0.0004	0.0034	1.7891	-0.0175	0.1335
0.0485	-0.0004	0.0035	1.9084	-0.0176	0.1363
0.0515	-0.0005	0.0035	2.0277	-0.0178	0.1375
0.0545	-0.0005	0.0035	2.1469	-0.0180	0.1372
0.0576	-0.0005	0.0034	2.2662	-0.0183	0.1354
0.0606	-0.0005	0.0034	2.3855	-0.0185	0.1320
0.0636	-0.0005	0.0032	2.5048	-0.0186	0.1271
0.0667	-0.0005	0.0031	2.6240	-0.0186	0.1208
0.0697	-0.0005	0.0029	2.7433	-0.0185	0.1131
0.0727	-0.0005	0.0026	2.8626	-0.0183	0.1040
0.0757	-0.0005	0.0024	2.9819	-0.0178	0.0936
0.0788	-0.0004	0.0021	3.1011	-0.0171	0.0820
0.0818	-0.0004	0.0018	3.2204	-0.0160	0.0692
0.0848	-0.0004	0.0014	3.3397	-0.0146	0.0553
0.0879	-0.0003	0.0010	3.4590	-0.0127	0.0403
0.0909	-0.0003	0.0006	3.5782	-0.0103	0.0243
0.0937	-0.0002	0.0002	3.6895	-0.0075	0.0087
0.0939	-0.0002	0.0002	3.6975	-0.0073	0.0075

RADIUS (METERS) = 0.3412 RADIUS (INCHES) = 13.434
CHORD (METERS) = 0.0939 CHORD (INCHES) = 3.6975
ZCSL (METERS) = 0.0489 ZCSL (INCHES) = 1.9271
YCSL (METERS) = 0.0011 YCSL (INCHES) = 0.0415
RLE (METERS) = 0.000207 RLE (INCHES) = 0.0081
RTE (METERS) = 0.000205 RTE (INCHES) = 0.0081
X-AREA(SQ.METERS) = 0.000252 X-AREA (SQ. IN.) = 0.3902
GAMMA-CHORD(DEG.) = 57.24 GAMMA-CHORD(RAD.) = 0.9990

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0079	0.0077
0.0002	-0.0002	0.0002	0.0082	-0.0080	0.0085
0.0030	-0.0002	0.0005	0.1197	-0.0094	0.0193
0.0061	-0.0003	0.0008	0.2394	-0.0109	0.0304
0.0091	-0.0003	0.0010	0.3590	-0.0123	0.0409
0.0122	-0.0003	0.0013	0.4787	-0.0137	0.0508
0.0152	-0.0004	0.0015	0.5984	-0.0151	0.0600
0.0182	-0.0004	0.0017	0.7181	-0.0166	0.0687
0.0213	-0.0005	0.0020	0.8378	-0.0180	0.0768
0.0243	-0.0005	0.0021	0.9574	-0.0193	0.0843
0.0274	-0.0005	0.0023	1.0771	-0.0206	0.0912
0.0304	-0.0006	0.0025	1.1968	-0.0219	0.0976
0.0334	-0.0006	0.0026	1.3165	-0.0230	0.1034
0.0365	-0.0006	0.0028	1.4361	-0.0241	0.1086
0.0395	-0.0006	0.0029	1.5558	-0.0253	0.1133
0.0426	-0.0007	0.0030	1.6755	-0.0263	0.1174
0.0456	-0.0007	0.0031	1.7952	-0.0270	0.1208
0.0486	-0.0007	0.0031	1.9149	-0.0278	0.1229
0.0517	-0.0007	0.0031	2.0345	-0.0285	0.1236
0.0547	-0.0007	0.0031	2.1542	-0.0289	0.1230
0.0578	-0.0007	0.0031	2.2739	-0.0293	0.1211
0.0608	-0.0007	0.0030	2.3936	-0.0295	0.1178
0.0638	-0.0007	0.0029	2.5133	-0.0294	0.1132
0.0669	-0.0007	0.0027	2.6329	-0.0290	0.1074
0.0699	-0.0007	0.0025	2.7526	-0.0284	0.1004
0.0730	-0.0007	0.0023	2.8723	-0.0275	0.0923
0.0760	-0.0007	0.0021	2.9920	-0.0261	0.0830
0.0790	-0.0006	0.0018	3.1117	-0.0243	0.0727
0.0821	-0.0006	0.0016	3.2313	-0.0221	0.0614
0.0851	-0.0005	0.0012	3.3510	-0.0194	0.0491
0.0882	-0.0004	0.0009	3.4707	-0.0160	0.0360
0.0912	-0.0003	0.0006	3.5904	-0.0120	0.0222
0.0940	-0.0002	0.0002	3.7020	-0.0077	0.0085
0.0942	-0.0002	0.0002	3.7101	-0.0074	0.0075

RADIUS (METERS) = 0.3458 RADIUS (INCHES) = 13.614
CHORD (METERS) = 0.0942 CHORD (INCHES) = 3.7101
ZCSL (METERS) = 0.0490 ZCSL (INCHES) = 1.9309
YCSL (METERS) = 0.0008 YCSL (INCHES) = 0.0328
RLE (METERS) = 0.000210 RLE (INCHES) = 0.0082
RTE (METERS) = 0.000205 RTE (INCHES) = 0.0081
X-AREA(SQ.METERS) = 0.000248 X-AREA (SQ. IN.) = 0.3843
GAMMA-CHORD(DEG.) = 57.84 GAMMA-CHORD(RAD.) = 1.0095

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0079	0.0078
0.0002	-0.0002	0.0002	0.0083	-0.0080	0.0085
0.0030	-0.0003	0.0005	0.1201	-0.0099	0.0187
0.0061	-0.0003	0.0007	0.2401	-0.0119	0.0291
0.0091	-0.0003	0.0010	0.3602	-0.0138	0.0390
0.0122	-0.0004	0.0012	0.4802	-0.0156	0.0482
0.0152	-0.0004	0.0014	0.6003	-0.0176	0.0568
0.0183	-0.0005	0.0016	0.7204	-0.0196	0.0648
0.0213	-0.0005	0.0018	0.8404	-0.0215	0.0722
0.0244	-0.0006	0.0020	0.9605	-0.0233	0.0790
0.0274	-0.0006	0.0022	1.0806	-0.0251	0.0852
0.0305	-0.0007	0.0023	1.2006	-0.0268	0.0909
0.0335	-0.0007	0.0024	1.3207	-0.0284	0.0960
0.0366	-0.0008	0.0026	1.4407	-0.0300	0.1006
0.0396	-0.0008	0.0027	1.5608	-0.0316	0.1047
0.0427	-0.0008	0.0027	1.6809	-0.0330	0.1082
0.0457	-0.0009	0.0028	1.8009	-0.0341	0.1112
0.0488	-0.0009	0.0029	1.9210	-0.0351	0.1130
0.0518	-0.0009	0.0029	2.0411	-0.0358	0.1136
0.0549	-0.0009	0.0029	2.1611	-0.0363	0.1130
0.0579	-0.0009	0.0028	2.2812	-0.0365	0.1112
0.0610	-0.0009	0.0027	2.4012	-0.0364	0.1082
0.0640	-0.0009	0.0026	2.5213	-0.0360	0.1041
0.0671	-0.0009	0.0025	2.6414	-0.0352	0.0988
0.0701	-0.0009	0.0023	2.7614	-0.0341	0.0924
0.0732	-0.0008	0.0022	2.8815	-0.0327	0.0851
0.0762	-0.0008	0.0019	3.0016	-0.0307	0.0766
0.0793	-0.0007	0.0017	3.1216	-0.0282	0.0672
0.0823	-0.0006	0.0014	3.2417	-0.0252	0.0569
0.0854	-0.0006	0.0012	3.3617	-0.0217	0.0458
0.0884	-0.0004	0.0009	3.4818	-0.0176	0.0337
0.0915	-0.0003	0.0005	3.6019	-0.0129	0.0209
0.0943	-0.0002	0.0002	3.7137	-0.0080	0.0085
0.0945	-0.0002	0.0002	3.7219	-0.0076	0.0075

RADIUS (METERS) = 0.3496 RADIUS (INCHES) = 13.764
CHORD (METERS) = 0.0945 CHORD (INCHES) = 3.7219
ZCSL (METERS) = 0.0492 ZCSL (INCHES) = 1.9363
YCSL (METERS) = 0.0007 YCSL (INCHES) = 0.0262
RLE (METERS) = 0.000210 RLE (INCHES) = 0.0083
RTE (METERS) = 0.000208 RTE (INCHES) = 0.0082
X-AREA(SQ.METERS) = 0.000245 X-AREA (SQ. IN.) = 0.3796
GAMMA-CHORD(DEG.) = 58.45 GAMMA-CHORD(RAD.) = 1.0201

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0077	0.0078
0.0002	-0.0002	0.0002	0.0082	-0.0079	0.0085
0.0031	-0.0003	0.0005	0.1206	-0.0104	0.0178
0.0061	-0.0003	0.0007	0.2412	-0.0131	0.0274
0.0092	-0.0004	0.0009	0.3619	-0.0157	0.0365
0.0123	-0.0005	0.0011	0.4825	-0.0182	0.0450
0.0153	-0.0005	0.0013	0.6031	-0.0207	0.0529
0.0184	-0.0006	0.0015	0.7237	-0.0231	0.0603
0.0214	-0.0006	0.0017	0.8444	-0.0254	0.0671
0.0245	-0.0007	0.0019	0.9650	-0.0277	0.0734
0.0276	-0.0008	0.0020	1.0856	-0.0298	0.0791
0.0306	-0.0008	0.0021	1.2063	-0.0318	0.0843
0.0337	-0.0009	0.0023	1.3269	-0.0337	0.0890
0.0368	-0.0009	0.0024	1.4475	-0.0354	0.0933
0.0398	-0.0009	0.0025	1.5681	-0.0370	0.0971
0.0429	-0.0010	0.0026	1.6888	-0.0384	0.1004
0.0460	-0.0010	0.0026	1.8094	-0.0396	0.1033
0.0490	-0.0010	0.0027	1.9300	-0.0405	0.1052
0.0521	-0.0010	0.0027	2.0506	-0.0411	0.1059
0.0551	-0.0011	0.0027	2.1713	-0.0415	0.1054
0.0582	-0.0011	0.0026	2.2919	-0.0415	0.1038
0.0613	-0.0010	0.0026	2.4125	-0.0411	0.1010
0.0643	-0.0010	0.0025	2.5331	-0.0404	0.0972
0.0674	-0.0010	0.0023	2.6538	-0.0394	0.0923
0.0705	-0.0010	0.0022	2.7744	-0.0380	0.0864
0.0735	-0.0009	0.0020	2.8950	-0.0362	0.0795
0.0766	-0.0009	0.0018	3.0156	-0.0338	0.0716
0.0797	-0.0008	0.0016	3.1363	-0.0308	0.0628
0.0827	-0.0007	0.0014	3.2569	-0.0275	0.0532
0.0858	-0.0006	0.0011	3.3775	-0.0236	0.0428
0.0889	-0.0005	0.0008	3.4981	-0.0189	0.0316
0.0919	-0.0003	0.0005	3.6188	-0.0135	0.0197
0.0948	-0.0002	0.0002	3.7314	-0.0078	0.0083
0.0950	-0.0002	0.0002	3.7394	-0.0074	0.0074

RADIUS (METERS) = 0.3534 RADIUS (INCHES) = 13.914
CHORD (METERS) = 0.0950 CHORD (INCHES) = 3.7394
ZCSL (METERS) = 0.0494 ZCSL (INCHES) = 1.9436
YCSL (METERS) = 0.0005 YCSL (INCHES) = 0.0210
RLE (METERS) = 0.000208 RLE (INCHES) = 0.0082
RTE (METERS) = 0.000204 RTE (INCHES) = 0.0080
X-AREA(SQ.METERS) = 0.000242 X-AREA (SQ. IN.) = 0.3755
GAMMA-CHORD(DEG.) = 59.14 GAMMA-CHORD(RAD.) = 1.0322

MANUFACTURING COORDINATES (Cont'd)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0076	0.0077
0.0002	-0.0002	0.0002	0.0081	-0.0079	0.0083
0.0031	-0.0003	0.0004	0.1215	-0.0115	0.0165
0.0062	-0.0004	0.0006	0.2430	-0.0153	0.0248
0.0093	-0.0005	0.0008	0.3645	-0.0189	0.0327
0.0123	-0.0006	0.0010	0.4860	-0.0224	0.0401
0.0154	-0.0007	0.0012	0.6075	-0.0258	0.0470
0.0185	-0.0007	0.0014	0.7290	-0.0289	0.0533
0.0216	-0.0008	0.0015	0.8505	-0.0320	0.0592
0.0247	-0.0009	0.0016	0.9720	-0.0349	0.0647
0.0278	-0.0010	0.0018	1.0934	-0.0376	0.0696
0.0309	-0.0010	0.0019	1.2149	-0.0401	0.0741
0.0339	-0.0011	0.0020	1.3364	-0.0424	0.0782
0.0370	-0.0011	0.0021	1.4579	-0.0444	0.0820
0.0401	-0.0012	0.0022	1.5794	-0.0462	0.0853
0.0432	-0.0012	0.0022	1.7009	-0.0477	0.0883
0.0463	-0.0012	0.0023	1.8224	-0.0490	0.0910
0.0494	-0.0013	0.0024	1.9439	-0.0499	0.0927
0.0525	-0.0013	0.0024	2.0654	-0.0504	0.0934
0.0555	-0.0013	0.0024	2.1869	-0.0507	0.0930
0.0586	-0.0013	0.0023	2.3084	-0.0506	0.0916
0.0617	-0.0013	0.0023	2.4299	-0.0501	0.0891
0.0648	-0.0012	0.0022	2.5514	-0.0492	0.0856
0.0679	-0.0012	0.0021	2.6729	-0.0477	0.0811
0.0710	-0.0012	0.0019	2.7944	-0.0458	0.0757
0.0741	-0.0011	0.0018	2.9159	-0.0434	0.0695
0.0771	-0.0010	0.0016	3.0374	-0.0403	0.0625
0.0802	-0.0009	0.0014	3.1589	-0.0366	0.0547
0.0833	-0.0008	0.0012	3.2803	-0.0324	0.0462
0.0864	-0.0007	0.0009	3.4018	-0.0274	0.0370
0.0895	-0.0005	0.0007	3.5233	-0.0213	0.0276
0.0926	-0.0004	0.0005	3.6448	-0.0146	0.0177
0.0955	-0.0002	0.0002	3.7585	-0.0077	0.0081
0.0957	-0.0002	0.0002	3.7663	-0.0072	0.0074

RADIUS (METERS) = 0.3587 — RADIUS (INCHES) = 14.124
CHORD (METERS) = 0.0957 — CHORD (INCHES) = 3.7663
ZCSL (METERS) = 0.0496 — ZCSL (INCHES) = 1.9509
YCSL (METERS) = 0.0003 — YCSL (INCHES) = 0.0127
RLE (METERS) =0.000205 — RLE (INCHES) = 0.0081
RTE (METERS) =0.000200 — RTE (INCHES) = 0.0079
X-AREA(SQ.METERS)=0.000239 — X-AREA (SQ. IN.) = 0.3706
GAMMA-CHORD(DEG.)= 60.19 — GAMMA-CHORD(RAD.)= 1.0505

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0076	0.0077
0.0002	-0.0002	0.0002	0.0081	-0.0080	0.0082
0.0031	-0.0003	0.0004	0.1222	-0.0124	0.0155
0.0062	-0.0004	0.0006	0.2443	-0.0170	0.0229
0.0093	-0.0005	0.0008	0.3665	-0.0214	0.0299
0.0124	-0.0007	0.0009	0.4886	-0.0257	0.0364
0.0155	-0.0008	0.0011	0.6108	-0.0297	0.0424
0.0186	-0.0009	0.0012	0.7330	-0.0335	0.0480
0.0217	-0.0009	0.0014	0.8551	-0.0371	0.0532
0.0248	-0.0010	0.0015	0.9773	-0.0405	0.0579
0.0279	-0.0011	0.0016	1.0994	-0.0436	0.0623
0.0310	-0.0012	0.0017	1.2216	-0.0464	0.0663
0.0341	-0.0012	0.0018	1.3438	-0.0490	0.0699
0.0372	-0.0013	0.0019	1.4659	-0.0512	0.0732
0.0403	-0.0013	0.0019	1.5881	-0.0531	0.0763
0.0434	-0.0014	0.0020	1.7102	-0.0545	0.0791
0.0465	-0.0014	0.0021	1.8324	-0.0556	0.0816
0.0496	-0.0014	0.0021	1.9545	-0.0562	0.0834
0.0527	-0.0014	0.0021	2.0767	-0.0565	0.0843
0.0559	-0.0014	0.0021	2.1989	-0.0563	0.0841
0.0590	-0.0014	0.0021	2.3210	-0.0557	0.0830
0.0621	-0.0014	0.0021	2.4432	-0.0547	0.0810
0.0652	-0.0013	0.0020	2.5653	-0.0531	0.0781
0.0683	-0.0013	0.0019	2.6875	-0.0510	0.0743
0.0714	-0.0012	0.0018	2.8097	-0.0483	0.0698
0.0745	-0.0011	0.0016	2.9318	-0.0451	0.0644
0.0776	-0.0011	0.0015	3.0540	-0.0413	0.0584
0.0807	-0.0009	0.0013	3.1761	-0.0370	0.0516
0.0838	-0.0008	0.0011	3.2983	-0.0321	0.0440
0.0869	-0.0007	0.0009	3.4205	-0.0267	0.0359
0.0900	-0.0005	0.0007	3.5426	-0.0206	0.0270
0.0931	-0.0004	0.0004	3.6648	-0.0141	0.0174
0.0960	-0.0002	0.0002	3.7791	-0.0076	0.0081
0.0962	-0.0002	0.0002	3.7869	-0.0072	0.0075

RADIUS (METERS) = 0.3628 — RADIUS (INCHES) = 14.284
CHORD (METERS) = 0.0962 — CHORD (INCHES) = 3.7869
ZCSL (METERS) = 0.0497 — ZCSL (INCHES) = 1.9554
YCSL (METERS) = 0.0002 — YCSL (INCHES) = 0.0067
RLE (METERS) =0.000205 — RLE (INCHES) = 0.0081
RTE (METERS) =0.000199 — RTE (INCHES) = 0.0078
X-AREA(SQ.METERS)=0.000236 — X-AREA (SQ. IN.) = 0.3653
GAMMA-CHORD(DEG.)= 61.03 — GAMMA-CHORD(RAD.)= 1.0652

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0077	0.0077
0.0002	-0.0002	0.0002	0.0081	-0.0081	0.0081
0.0031	-0.0003	0.0004	0.1227	-0.0134	0.0143
0.0062	-0.0005	0.0005	0.2455	-0.0188	0.0206
0.0094	-0.0006	0.0007	0.3683	-0.0239	0.0265
0.0125	-0.0007	0.0008	0.4910	-0.0288	0.0320
0.0156	-0.0008	0.0009	0.6138	-0.0334	0.0372
0.0187	-0.0010	0.0011	0.7365	-0.0376	0.0420
0.0218	-0.0011	0.0012	0.8593	-0.0416	0.0465
0.0249	-0.0011	0.0013	0.9820	-0.0452	0.0507
0.0281	-0.0012	0.0014	1.1048	-0.0485	0.0546
0.0312	-0.0013	0.0015	1.2275	-0.0513	0.0583
0.0343	-0.0014	0.0016	1.3503	-0.0538	0.0617
0.0374	-0.0014	0.0016	1.4730	-0.0558	0.0649
0.0405	-0.0015	0.0017	1.5958	-0.0573	0.0679
0.0437	-0.0015	0.0018	1.7186	-0.0582	0.0710
0.0468	-0.0015	0.0019	1.8413	-0.0585	0.0739
0.0499	-0.0015	0.0019	1.9641	-0.0584	0.0763
0.0530	-0.0015	0.0020	2.0868	-0.0578	0.0779
0.0561	-0.0014	0.0020	2.2096	-0.0569	0.0786
0.0592	-0.0014	0.0020	2.3323	-0.0556	0.0782
0.0624	-0.0014	0.0020	2.4551	-0.0538	0.0769
0.0655	-0.0013	0.0019	2.5778	-0.0516	0.0747
0.0686	-0.0012	0.0018	2.7006	-0.0491	0.0716
0.0717	-0.0012	0.0017	2.8233	-0.0460	0.0676
0.0748	-0.0011	0.0016	2.9461	-0.0424	0.0628
0.0779	-0.0010	0.0015	3.0689	-0.0384	0.0573
0.0811	-0.0009	0.0013	3.1916	-0.0340	0.0509
0.0842	-0.0007	0.0011	3.3144	-0.0293	0.0437
0.0873	-0.0006	0.0009	3.4371	-0.0242	0.0357
0.0904	-0.0005	0.0007	3.5599	-0.0188	0.0270
0.0935	-0.0003	0.0004	3.6826	-0.0131	0.0176
0.0965	-0.0002	0.0002	3.7976	-0.0075	0.0081
0.0967	-0.0002	0.0002	3.8054	-0.0072	0.0074

RADIUS (METERS) = 0.3676 — RADIUS (INCHES) = 14.474
CHORD (METERS) = 0.0967 — CHORD (INCHES) = 3.8054
ZCSL (METERS) = 0.0498 — ZCSL (INCHES) = 1.9607
YCSL (METERS) = 0.0001 — YCSL (INCHES) = 0.0034
RLE (METERS) =0.000206 — RLE (INCHES) = 0.0081
RTE (METERS) =0.000198 — RTE (INCHES) = 0.0078
X-AREA(SQ.METERS)=0.000229 — X-AREA (SQ. IN.) = 0.3552
GAMMA-CHORD(DEG.)= 62.03 — GAMMA-CHORD(RAD.)= 1.0826

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0077	0.0075
0.0002	-0.0002	0.0002	0.0079	-0.0082	0.0076
0.0033	-0.0004	0.0002	0.1290	-0.0155	0.0098
0.0066	-0.0006	0.0003	0.2579	-0.0229	0.0122
0.0098	-0.0008	0.0004	0.3869	-0.0296	0.0147
0.0131	-0.0009	0.0004	0.5159	-0.0357	0.0172
0.0164	-0.0010	0.0005	0.6448	-0.0412	0.0199
0.0197	-0.0012	0.0006	0.7738	-0.0460	0.0226
0.0229	-0.0013	0.0006	0.9028	-0.0502	0.0254
0.0262	-0.0014	0.0007	1.0317	-0.0538	0.0284
0.0295	-0.0014	0.0008	1.1607	-0.0567	0.0314
0.0328	-0.0015	0.0009	1.2897	-0.0589	0.0346
0.0360	-0.0015	0.0010	1.4186	-0.0605	0.0379
0.0393	-0.0016	0.0010	1.5476	-0.0614	0.0413
0.0426	-0.0016	0.0011	1.6766	-0.0615	0.0449
0.0459	-0.0015	0.0012	1.8055	-0.0608	0.0488
0.0491	-0.0015	0.0013	1.9345	-0.0595	0.0526
0.0524	-0.0015	0.0014	2.0635	-0.0574	0.0567
0.0557	-0.0014	0.0015	2.1924	-0.0550	0.0599
0.0590	-0.0013	0.0016	2.3214	-0.0526	0.0620
0.0622	-0.0013	0.0016	2.4504	-0.0501	0.0630
0.0655	-0.0012	0.0016	2.5794	-0.0475	0.0629
0.0688	-0.0011	0.0016	2.7083	-0.0448	0.0618
0.0721	-0.0011	0.0015	2.8373	-0.0419	0.0598
0.0753	-0.0010	0.0014	2.9663	-0.0388	0.0569
0.0786	-0.0009	0.0013	3.0952	-0.0355	0.0531
0.0819	-0.0008	0.0012	3.2242	-0.0320	0.0486
0.0852	-0.0007	0.0011	3.3532	-0.0284	0.0433
0.0884	-0.0006	0.0009	3.4821	-0.0245	0.0373
0.0917	-0.0005	0.0008	3.6111	-0.0204	0.0307
0.0950	-0.0004	0.0006	3.7401	-0.0162	0.0234
0.0983	-0.0003	0.0004	3.8690	-0.0120	0.0154
0.1014	-0.0002	0.0002	3.9906	-0.0071	0.0077
0.1015	-0.0002	0.0002	3.9980	-0.0068	0.0072

RADIUS (METERS) = 0.3892 — RADIUS (INCHES) =15.324
CHORD (METERS) = 0.1015 — CHORD (INCHES) = 3.9980
ZCSL (METERS) = 0.0521 — ZCSL (INCHES) = 2.0495
YCSL (METERS) = -0.0001 — YCSL (INCHES) =-0.0024
RLE (METERS) =0.000201 — RLE (INCHES) = 0.0079
RTE (METERS) =0.000187 — RTE (INCHES) = 0.0074
X-AREA(SQ.METERS)=0.000205 — X-AREA (SQ. IN.) = 0.3180
GAMMA-CHORD(DEG.)= 65.81 — GAMMA-CHORD(RAD.)= 1.1486

MANUFACTURING COORDINATES (Cont'd)

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0078	0.0075
0.0002	-0.0002	0.0002	0.0079	-0.0084	0.0075
0.0034	-0.0004	0.0002	0.1329	-0.0175	0.0078
0.0068	-0.0007	0.0002	0.2659	-0.0266	0.0083
0.0101	-0.0009	0.0002	0.3988	-0.0349	0.0089
0.0135	-0.0011	0.0002	0.5318	-0.0426	0.0096
0.0169	-0.0013	0.0003	0.6647	-0.0496	0.0105
0.0203	-0.0014	0.0003	0.7976	-0.0558	0.0116
0.0236	-0.0016	0.0003	0.9306	-0.0612	0.0129
0.0270	-0.0017	0.0004	1.0635	-0.0658	0.0144
0.0304	-0.0018	0.0004	1.1965	-0.0697	0.0162
0.0338	-0.0018	0.0005	1.3294	-0.0725	0.0182
0.0371	-0.0019	0.0005	1.4624	-0.0745	0.0207
0.0405	-0.0019	0.0006	1.5953	-0.0754	0.0236
0.0439	-0.0019	0.0007	1.7282	-0.0754	0.0270
0.0473	-0.0019	0.0008	1.8612	-0.0740	0.0310
0.0507	-0.0018	0.0009	1.9941	-0.0717	0.0353
0.0540	-0.0017	0.0010	2.1271	-0.0683	0.0403
0.0574	-0.0016	0.0011	2.2600	-0.0645	0.0445
0.0608	-0.0015	0.0012	2.3929	-0.0604	0.0476
0.0642	-0.0014	0.0013	2.5259	-0.0561	0.0500
0.0675	-0.0013	0.0013	2.6588	-0.0516	0.0518
0.0709	-0.0012	0.0013	2.7918	-0.0469	0.0528
0.0743	-0.0011	0.0013	2.9247	-0.0420	0.0530
0.0777	-0.0009	0.0013	3.0577	-0.0371	0.0522
0.0810	-0.0008	0.0013	3.1906	-0.0323	0.0505
0.0844	-0.0007	0.0012	3.3235	-0.0275	0.0480
0.0878	-0.0006	0.0011	3.4565	-0.0229	0.0444
0.0912	-0.0005	0.0010	3.5894	-0.0186	0.0396
0.0945	-0.0004	0.0009	3.7224	-0.0146	0.0337
0.0979	-0.0003	0.0007	3.8553	-0.0113	0.0264
0.1013	-0.0002	0.0004	3.9882	-0.0086	0.0176
0.1045	-0.0002	0.0002	4.1128	-0.0070	0.0079
0.1047	-0.0002	0.0002	4.1212	-0.0069	0.0073

RADIUS (METERS) = 0.3974	RADIUS (INCHES) = 15.644
CHORD (METERS) = 0.1047	CHORD (INCHES) = 4.1212
ZCSL (METERS) = 0.0533	ZCSL (INCHES) = 2.0996
YCSL (METERS) = -0.0003	YCSL (INCHES) = -0.0137
RLE (METERS) = 0.000202	RLE (INCHES) = 0.0079
RTE (METERS) = 0.000189	RTE (INCHES) = 0.0074
X-AREA(SQ.METERS) = 0.000202	X-AREA (SQ. IN.) = 0.3132
GAMMA-CHORD(DEG.) = 67.29	GAMMA-CHORD(RAD.) = 1.1744

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0080	0.0078
0.0002	-0.0002	0.0002	0.0082	-0.0087	0.0077
0.0035	-0.0005	0.0002	0.1391	-0.0191	0.0060
0.0071	-0.0007	0.0001	0.2781	-0.0294	0.0047
0.0106	-0.0010	0.0001	0.4172	-0.0387	0.0038
0.0141	-0.0012	0.0001	0.5562	-0.0470	0.0034
0.0177	-0.0014	0.0001	0.6953	-0.0541	0.0035
0.0212	-0.0015	0.0001	0.8343	-0.0601	0.0042
0.0247	-0.0016	0.0001	0.9734	-0.0649	0.0055
0.0283	-0.0017	0.0002	1.1125	-0.0685	0.0075
0.0318	-0.0018	0.0003	1.2515	-0.0709	0.0102
0.0353	-0.0018	0.0003	1.3906	-0.0718	0.0136
0.0389	-0.0018	0.0005	1.5296	-0.0714	0.0179
0.0424	-0.0018	0.0006	1.6687	-0.0696	0.0232
0.0459	-0.0017	0.0007	1.8078	-0.0662	0.0294
0.0494	-0.0016	0.0009	1.9468	-0.0612	0.0372
0.0530	-0.0014	0.0012	2.0859	-0.0546	0.0457
0.0565	-0.0012	0.0014	2.2249	-0.0475	0.0540
0.0600	-0.0010	0.0016	2.3640	-0.0405	0.0613
0.0636	-0.0009	0.0017	2.5030	-0.0338	0.0672
0.0671	-0.0007	0.0018	2.6421	-0.0275	0.0717
0.0706	-0.0005	0.0019	2.7812	-0.0216	0.0749
0.0742	-0.0004	0.0019	2.9202	-0.0162	0.0767
0.0777	-0.0003	0.0020	3.0593	-0.0113	0.0772
0.0812	-0.0002	0.0019	3.1983	-0.0069	0.0762
0.0848	-0.0001	0.0019	3.3374	-0.0032	0.0738
0.0883	-0.0000	0.0018	3.4765	-0.0002	0.0699
0.0918	0.0000	0.0016	3.6155	0.0019	0.0645
0.0954	0.0001	0.0015	3.7546	0.0028	0.0572
0.0989	0.0001	0.0012	3.8936	0.0025	0.0478
0.1024	0.0000	0.0009	4.0327	0.0009	0.0365
0.1060	-0.0001	0.0006	4.1717	-0.0023	0.0229
0.1093	-0.0002	0.0002	4.3034	-0.0068	0.0081
0.1095	-0.0002	0.0002	4.3108	-0.0071	0.0073

RADIUS (METERS) = 0.4075	RADIUS (INCHES) = 16.044
CHORD (METERS) = 0.1095	CHORD (INCHES) = 4.3108
ZCSL (METERS) = 0.0554	ZCSL (INCHES) = 2.1829
YCSL (METERS) = -0.0000	YCSL (INCHES) = -0.0016
RLE (METERS) = 0.000208	RLE (INCHES) = 0.0082
RTE (METERS) = 0.000189	RTE (INCHES) = 0.0074
X-AREA(SQ.METERS) = 0.000199	X-AREA (SQ. IN.) = 0.3081
GAMMA-CHORD(DEG.) = 69.19	GAMMA-CHORD(RAD.) = 1.2076

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0081	0.0078
0.0002	-0.0002	0.0002	0.0082	-0.0088	0.0077
0.0036	-0.0005	0.0001	0.1430	-0.0198	0.0050
0.0073	-0.0008	0.0001	0.2860	-0.0307	0.0027
0.0109	-0.0010	0.0000	0.4290	-0.0403	0.0010
0.0145	-0.0012	0.0000	0.5719	-0.0486	0.0000
0.0182	-0.0014	-0.0000	0.7149	-0.0557	-0.0002
0.0218	-0.0016	0.0000	0.8579	-0.0614	0.0005
0.0254	-0.0017	0.0000	1.0009	-0.0657	0.0019
0.0291	-0.0017	0.0001	1.1439	-0.0685	0.0043
0.0327	-0.0018	0.0002	1.2869	-0.0699	0.0077
0.0363	-0.0018	0.0003	1.4299	-0.0696	0.0121
0.0400	-0.0017	0.0005	1.5728	-0.0678	0.0178
0.0436	-0.0016	0.0006	1.7158	-0.0642	0.0245
0.0472	-0.0015	0.0008	1.8588	-0.0588	0.0325
0.0508	-0.0013	0.0011	2.0018	-0.0516	0.0427
0.0545	-0.0011	0.0014	2.1448	-0.0422	0.0536
0.0581	-0.0008	0.0016	2.2878	-0.0328	0.0640
0.0617	-0.0006	0.0019	2.4308	-0.0239	0.0733
0.0654	-0.0004	0.0021	2.5737	-0.0157	0.0809
0.0690	-0.0002	0.0022	2.7167	-0.0084	0.0867
0.0726	-0.0000	0.0023	2.8597	-0.0019	0.0907
0.0763	0.0001	0.0024	3.0027	0.0038	0.0930
0.0799	0.0002	0.0024	3.1457	0.0085	0.0935
0.0835	0.0003	0.0023	3.2887	0.0122	0.0923
0.0872	0.0004	0.0023	3.4316	0.0148	0.0891
0.0908	0.0004	0.0021	3.5746	0.0162	0.0840
0.0944	0.0004	0.0020	3.7176	0.0165	0.0770
0.0981	0.0004	0.0017	3.8606	0.0154	0.0677
0.1017	0.0003	0.0014	4.0036	0.0127	0.0562
0.1053	0.0002	0.0011	4.1466	0.0082	0.0424
0.1090	0.0000	0.0007	4.2896	0.0016	0.0260
0.1124	-0.0002	0.0002	4.4252	-0.0067	0.0081
0.1126	-0.0002	0.0002	4.4325	-0.0071	0.0071

RADIUS (METERS) = 0.4131	RADIUS (INCHES) = 16.264
CHORD (METERS) = 0.1126	CHORD (INCHES) = 4.4326
ZCSL (METERS) = 0.0570	ZCSL (INCHES) = 2.2440
YCSL (METERS) = 0.0002	YCSL (INCHES) = 0.0065
RLE (METERS) = 0.000208	RLE (INCHES) = 0.0082
RTE (METERS) = 0.000186	RTE (INCHES) = 0.0073
X-AREA(SQ.METERS) = 0.000196	X-AREA (SQ. IN.) = 0.3044
GAMMA-CHORD(DEG.) = 70.16	GAMMA-CHORD(RAD.) = 1.2245

METERS			INCHES		
ZC	YP	YS	ZC	YP	YS
0.0	-0.0002	0.0002	0.0	-0.0080	0.0079
0.0002	-0.0002	0.0002	0.0081	-0.0086	0.0078
0.0038	-0.0005	0.0001	0.1511	-0.0189	0.0045
0.0077	-0.0007	0.0001	0.3022	-0.0282	0.0025
0.0115	-0.0009	0.0000	0.4532	-0.0359	0.0016
0.0153	-0.0011	0.0000	0.6043	-0.0421	0.0017
0.0192	-0.0012	0.0001	0.7554	-0.0467	0.0029
0.0230	-0.0013	0.0001	0.9065	-0.0496	0.0056
0.0269	-0.0013	0.0002	1.0576	-0.0510	0.0096
0.0307	-0.0013	0.0004	1.2086	-0.0507	0.0146
0.0345	-0.0012	0.0005	1.3597	-0.0486	0.0210
0.0384	-0.0011	0.0007	1.5108	-0.0448	0.0288
0.0422	-0.0010	0.0010	1.6619	-0.0393	0.0381
0.0460	-0.0008	0.0012	1.8130	-0.0318	0.0488
0.0499	-0.0006	0.0015	1.9641	-0.0229	0.0610
0.0537	-0.0003	0.0019	2.1151	-0.0125	0.0754
0.0576	0.0000	0.0023	2.2662	0.0006	0.0894
0.0614	0.0003	0.0026	2.4173	0.0125	0.1024
0.0652	0.0006	0.0029	2.5684	0.0232	0.1135
0.0691	0.0008	0.0031	2.7195	0.0327	0.1224
0.0729	0.0010	0.0033	2.8705	0.0406	0.1290
0.0767	0.0012	0.0034	3.0216	0.0471	0.1331
0.0806	0.0013	0.0034	3.1727	0.0521	0.1348
0.0844	0.0014	0.0034	3.3238	0.0556	0.1341
0.0883	0.0015	0.0033	3.4749	0.0575	0.1312
0.0921	0.0015	0.0032	3.6260	0.0574	0.1259
0.0959	0.0014	0.0030	3.7770	0.0554	0.1176
0.0998	0.0013	0.0027	3.9281	0.0516	0.1071
0.1036	0.0012	0.0024	4.0792	0.0458	0.0935
0.1074	0.0010	0.0019	4.2303	0.0374	0.0767
0.1113	0.0007	0.0014	4.3814	0.0262	0.0568
0.1151	0.0003	0.0009	4.5324	0.0116	0.0336
0.1188	-0.0002	0.0002	4.6768	-0.0061	0.0076
0.1190	-0.0002	0.0002	4.6835	-0.0069	0.0064

RADIUS (METERS) = 0.4250	RADIUS (INCHES) = 16.734
CHORD (METERS) = 0.1190	CHORD (INCHES) = 4.6835
ZCSL (METERS) = 0.0600	ZCSL (INCHES) = 2.3636
YCSL (METERS) = 0.0010	YCSL (INCHES) = 0.0402
RLE (METERS) = 0.000207	RLE (INCHES) = 0.0082
RTE (METERS) = 0.000172	RTE (INCHES) = 0.0068
X-AREA(SQ.METERS) = 0.000190	X-AREA (SQ. IN.) = 0.2945
GAMMA-CHORD(DEG.) = 72.46	GAMMA-CHORD(RAD.) = 1.2647